WHAT FORESTS GIVE

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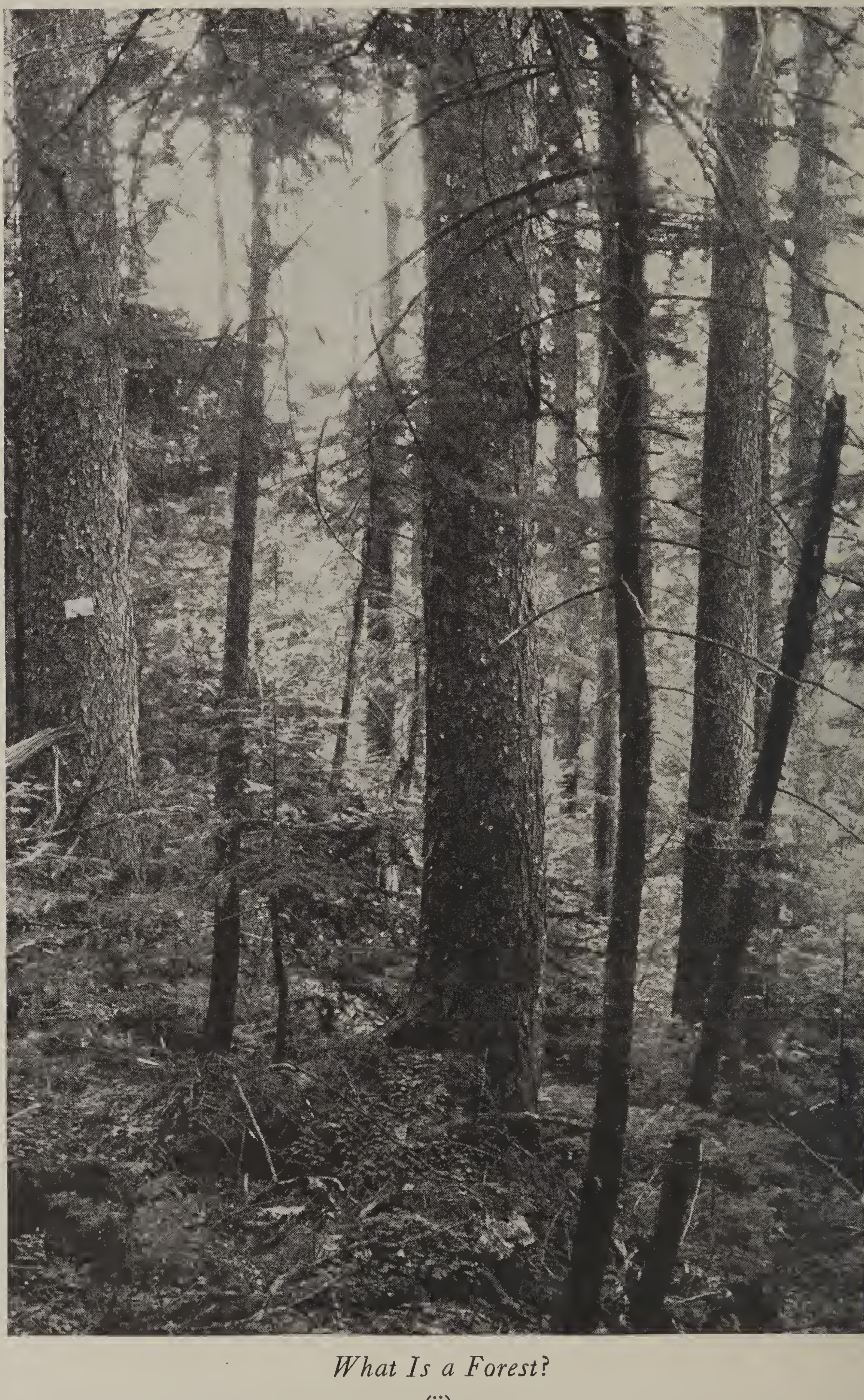

What Is a Forest?

(ii)

FOREWORD

Forests the world over are today being treated by wise nations not only as important sources of building materials but also as great storehouses from which can be derived through the magic of modern chemistry a wide variety of products valuable for man's use. These now include benzine, gasoline, acetone, alcohols, turpentine, cellulose, and sugars, and the chemists are finding other new products not hitherto known to exist in wood.

The great fact is that this resource can be a perpetual source of wealth because it grows and can be cropped instead of mined.

Forests are more than just a source of wealth—they are the conservators of soil and water without which there can be no permanent foundation for a growing civilization.

Recreation finds its greatest outlet in the forest areas and the variety of interests they afford.

To the boys and girls of the coming generations, this small illustrated volume and its complement, Taming Our Forests, are dedicated, because the future forests are their forests, and how they treat them will determine what the forests will and can do.

F. A. Silcox,
Chief, Forest Service.

WHAT FORESTS GIVE

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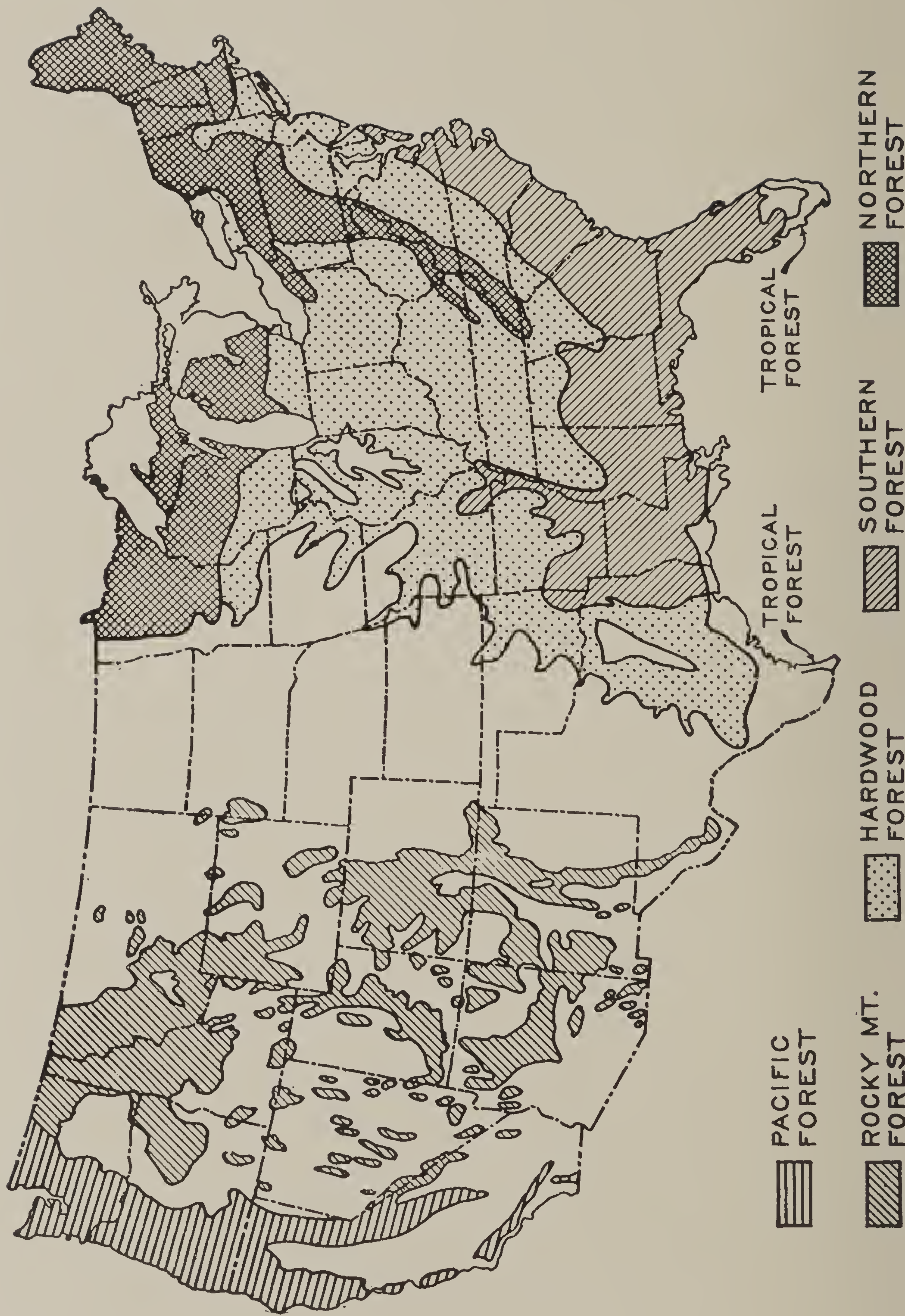


Forest Regions

FORESTS

Nearly one-third of the United States is forest land. What does this mean to the 127,000,000 people who live in our country?

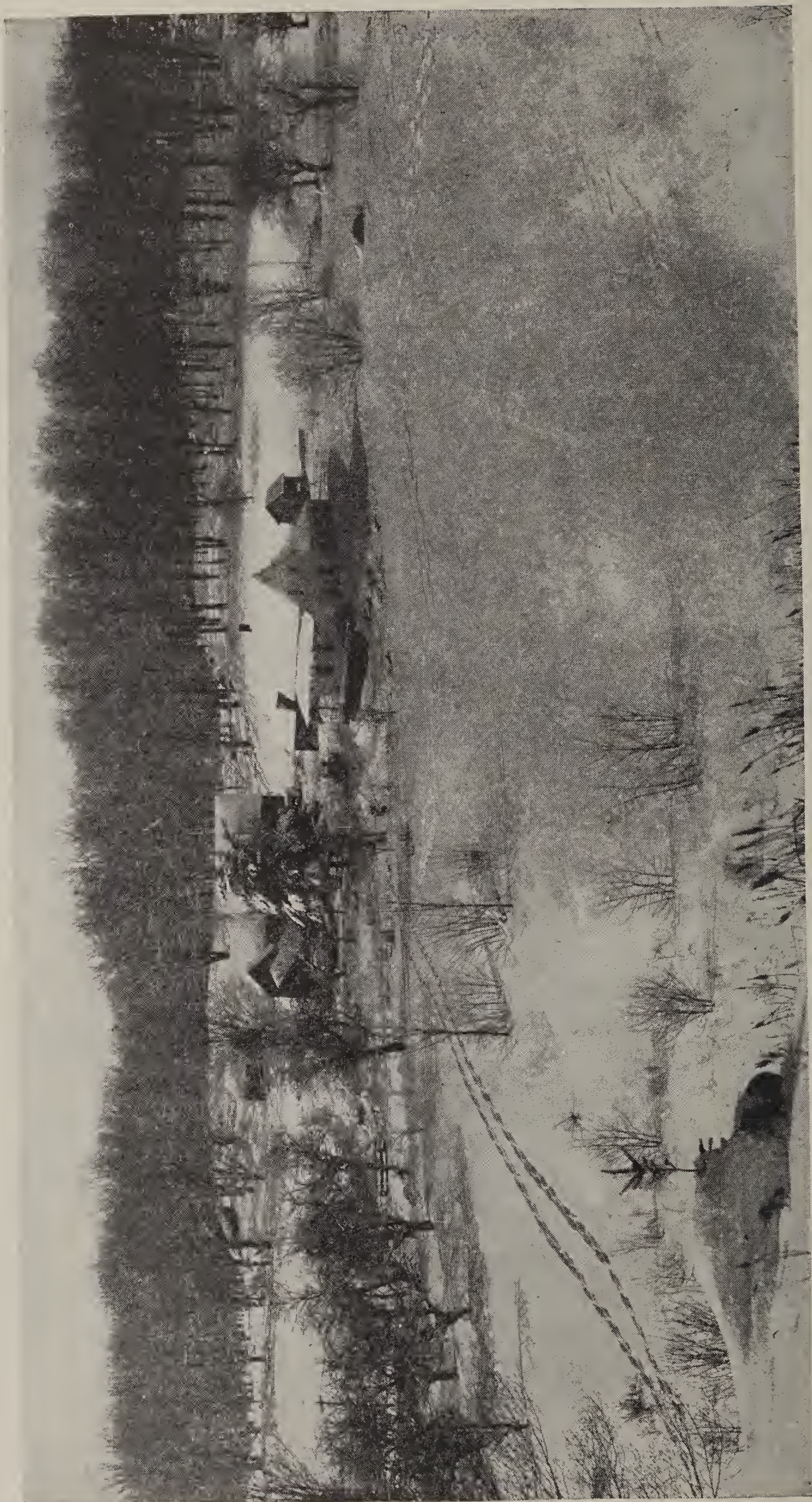
WHAT IS A FOREST?

A forest is more than land covered with trees. It is a community of plants and animals, of which trees are the most important members. Each living thing in a forest gives something to the common store of food. The plants, from the smallest mosses to the tallest trees, take material from the soil and the air and with the aid of sunlight create living protoplasm on which animals and other plants can feed. When plants and animals die, the bacteria and other living things change them into substances which enrich the soil, so that the forest grows more prosperous century by century.

But a forest is not a community at peace. Each living thing within it is struggling for food and light and space. Sometimes one group will entirely destroy another. Within a forest there is always merciless civil war.

Neither are forests at peace with their neighbors. They invade bogs and prairies and deserts, and they continually try to retake the fields which men have cleared for farms. Trees throw their seeds out upon the currents of air and water; they force their roots into the meadows and send up shoots. Forest animals make raids outside their own territory. There are marshes and seacoasts which forests have taken over; there are deserts from which they have had to retreat; snow and ice drive them back from the mountain tops; water comes to flood them out. They expand or contract as other communities of living beings give way before them or push them back.

What can we human beings get from these restless, struggling forests, from our 630,000,000 acres of forest land?



Farmer's Woodlot—New Hampshire

Two hundred years ago this would have been an easy question to answer.

When one of our wise great-grandfathers looked over his land he probably asked himself:

"If I leave that south 40 acres for a wood lot, what'll I get from it?"

He knew there was the wood for the great fireplace where the food was cooked. There were boards to repair the house, the old part of which was of logs and the newer wing of clapboards. During the winter he'd cut down one or two of the hard maples he didn't need for sugar, and the chestnut tree that grew the poorest nuts and make them into chairs and tables. That butternut tree would give all the dye his wife wanted for the linsey-woolsey she wove. There were as many squirrels in the trees as there were nuts to feed them, and nothing was better for a Sunday dinner than squirrel potpie; nor anything that felt better around the neck when the snow flew, than a squirrel skin. There'd be a wild turkey for Thanksgiving, perhaps. If a fox or wolf made a den under the roots of the fallen hickory—why the skin of either of them would help make a fine lap robe in the sleigh.

If our great-grandfathers should come back they wouldn't know their country. Wherever those hardy Europeans had struggled through the waves to set foot on the Atlantic coast, they met a solid phalanx of trees, from Maine to Florida. So far as they could see, this America was one continuous forest! For a hundred years their children and grandchildren who pushed steadily west through thick woods must have thought the same thing. Not until a later generation had gone down the western slopes of the Appalachians did the white men come out of the forests upon the prairies. The Great Valley of the Mississippi which lay ahead was threaded with streams, and trees grew along their banks, but there were no forests. During the next 40 years the settlers pushed on west through prairie grass so tall that it swished their boot tops. Whenever the long lines of their covered wagons broke through the thick soft mat of grass roots, the tires were in heavy black earth. Generations of pioneers followed each other down to

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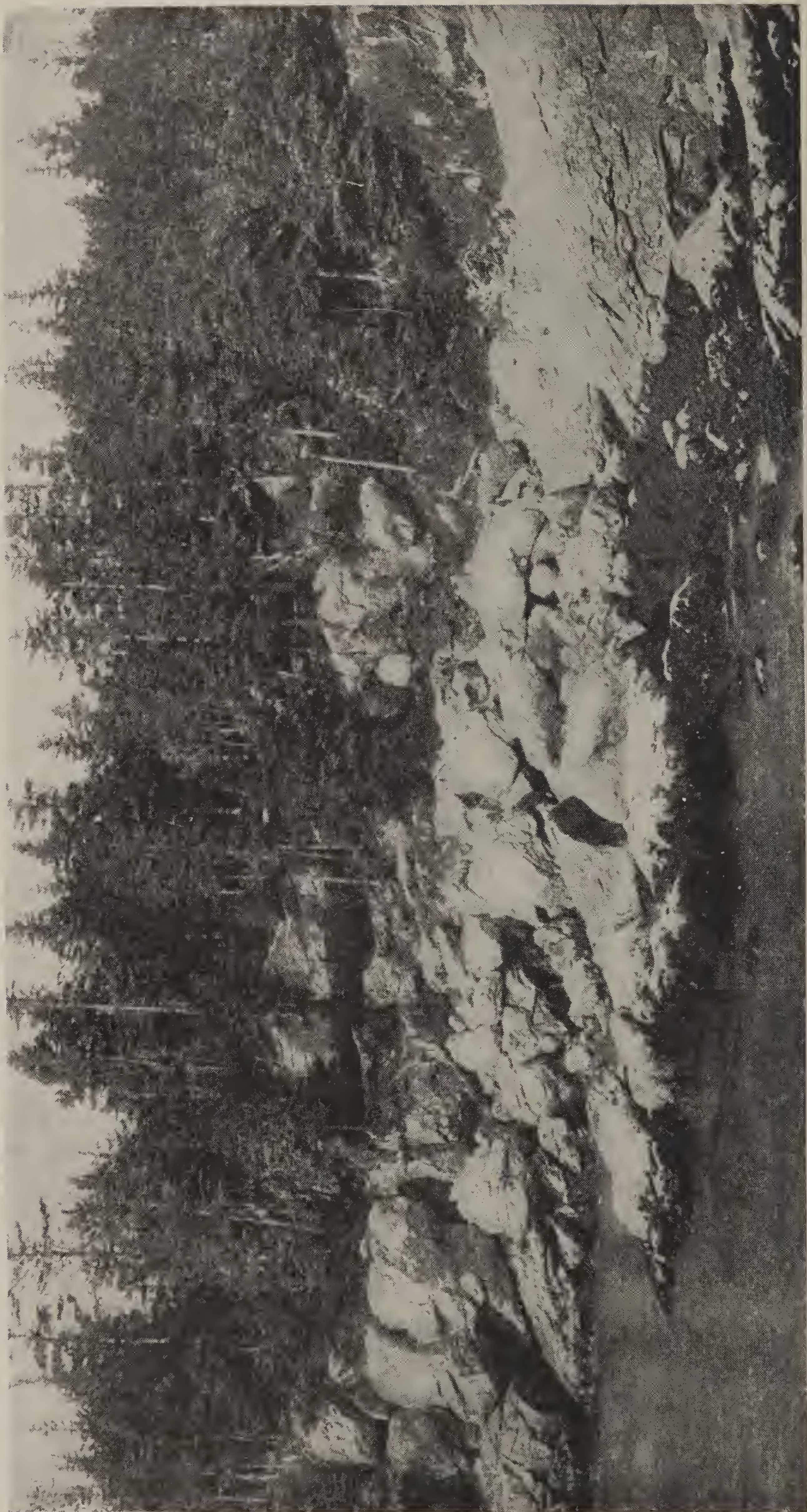
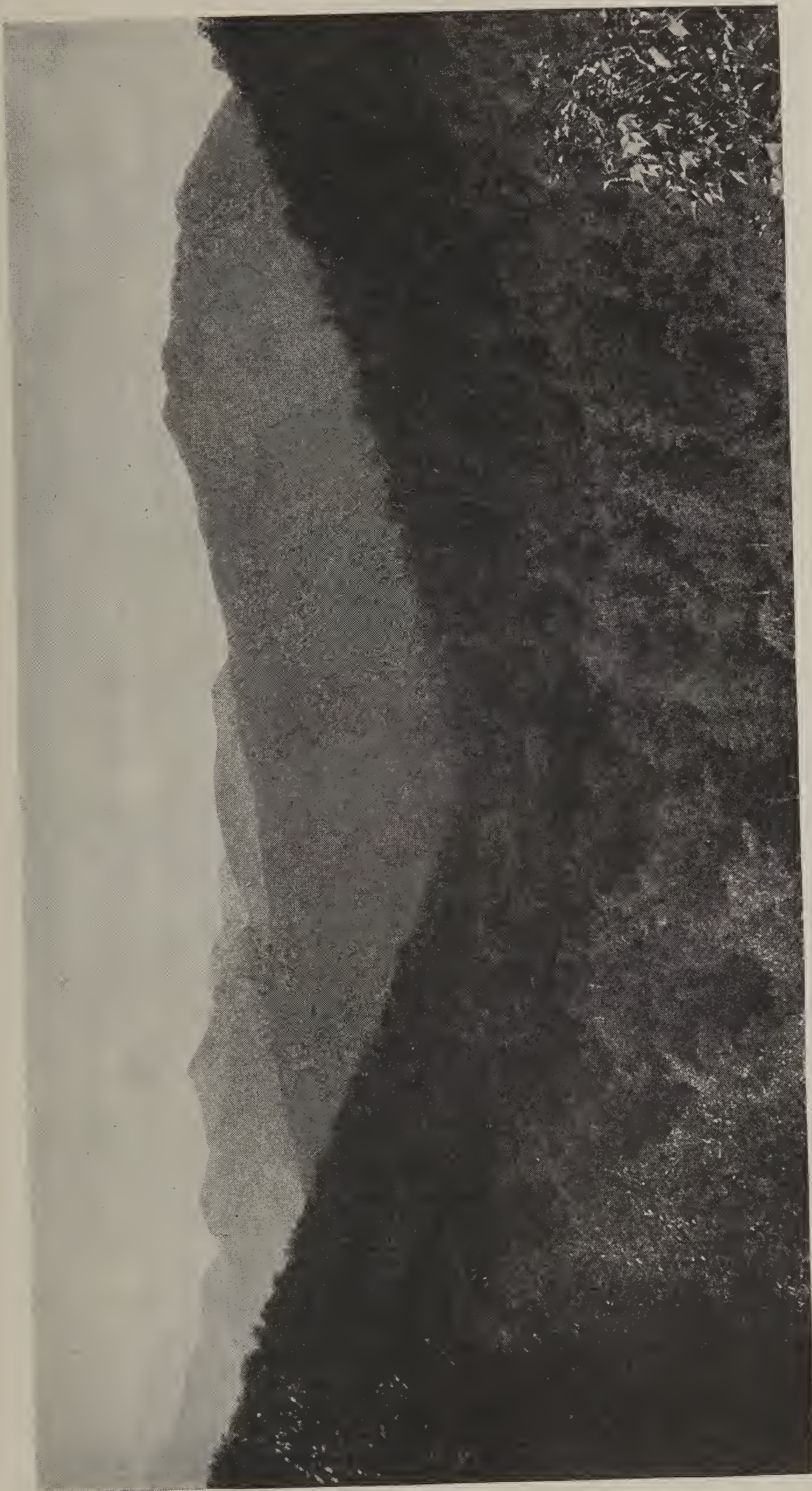


New England Coast



One Continuous Forest

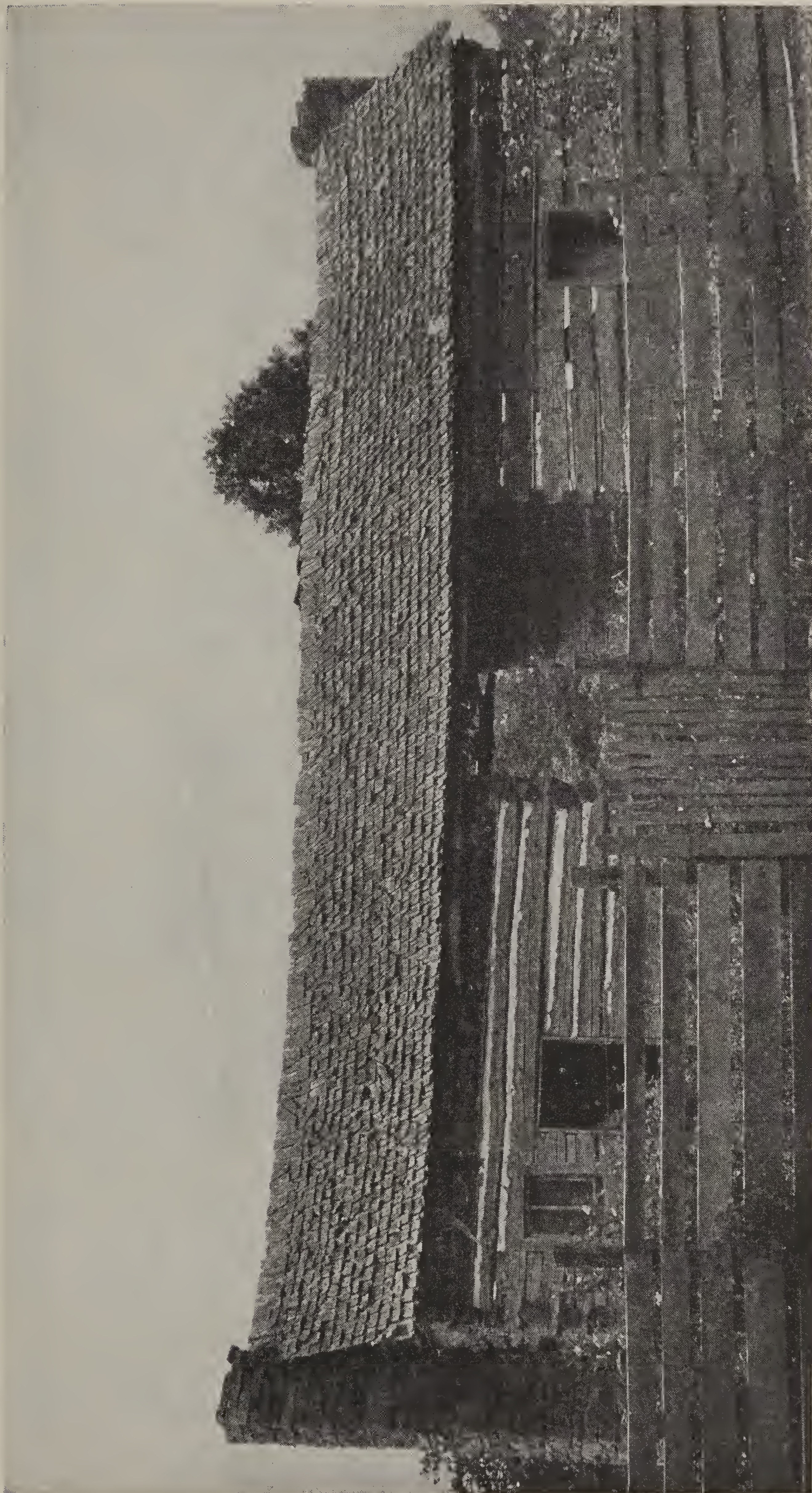
the Mississippi, boated across it, went on over hundreds of miles of prairie, and pulled up to high ground. Here the long grass was done, and their wagon wheels rolled merrily through short thin grasses, on a hard, dry, flat surface without a tree in sight. A land the like of which neither they nor their ancestors to the remotest generations had ever heard of—the Plains!

Not within the memory of man, savage or civilized, had there been forests on those high plains. Not any forests since the Rockies rose up to cut off the rain clouds from the West and the great inland sea drained away through the Gulf of Mexico and the St. Lawrence. After the grass had had time to cover the plains, the land became the pasture place of buffalo and antelope, and the hunting ground of Indians. Pioneers pushing on across the high plains came again into a land of forests—the Rocky Mountains thick with trees. Trees covered the steep slopes up to the snow line and down on the western sides to the Pacific's edge. Half the land the pioneers had crossed between ocean and ocean was forest land.

When the long march of the settlers toward the West began, there were only 884,000 white people in the country, and there were nearly 900,000,000 acres of forests. Although their way of living depended on having all the wood and other forest products they chose to use, these men did not know how to use them for many things. Now there are 127,000,000 of us, we have only 630,000,000 acres of forest land left, and we want from forests things of which our great-grandfathers never dreamed.

How can we get what we want?

Take for instance the wood we use for houses. Our great-grandfathers' homes were built of whole tree trunks piled one on another. No more was done to a tree than to fell it, cut the trunk the right length, notch it near the ends so that it would fit between the other logs that were laid at right angles to it. Often the bark was left on. It took a great many trees to build a small log house—trees that might have been a hundred years growing. If we all lived now in houses that took so many large trees to build, we should have few forests left.



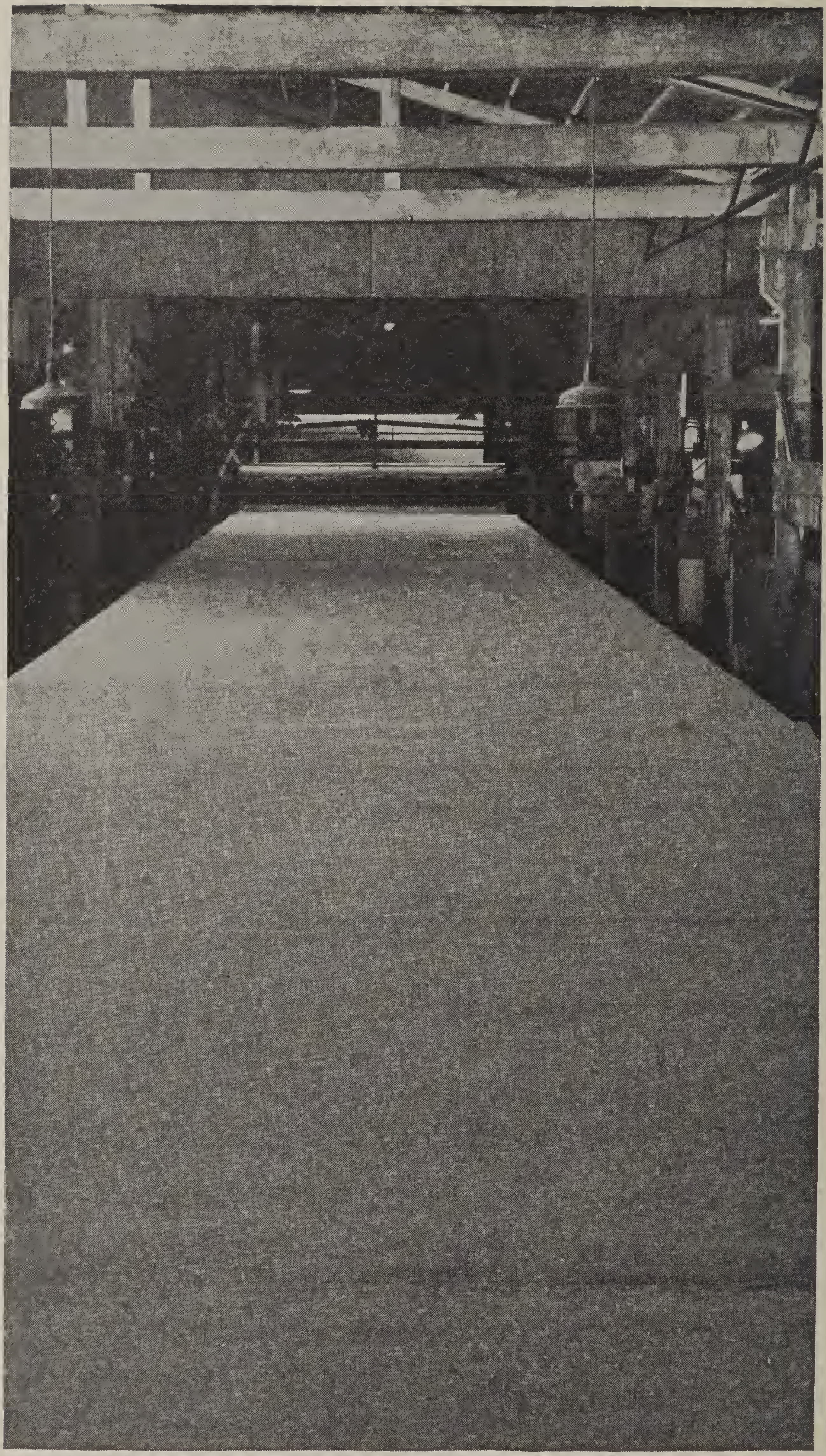
Log Cabin—East Tennessee

After sawmills were built where there was water power to run them, the great logs could be divided into boards and timbers. Good boards were cut from trees that were neither very large nor very old, and houses built of clapboards and shingles took fewer trees and were far more comfortable.

Though some of these early houses of wood have lasted very well, they do not meet our needs and standards today. There is one of them near Dedham, Mass., built by a well-to-do gentleman about 1700. It had all the modern conveniences of that time. It was heated, for in the living room, which was also the kitchen, is a great fireplace taking up most of one side. The spit on which meats were roasted and the cranes on which kettles were hung are still in place. The glass in the tiny windows was brought from England, and the small uneven panes have turned pinkish-purple through the years. The sleeping rooms had no heat at all, but there were great ticks stuffed with feathers, one to sleep on, one to sleep under. There was a good water supply—a well a hundred feet from the side door with a bucket drawn up by a chain. There were no clothes closets in this old house. Mother's other dress and father's Sunday suit hung on wooden pegs against the walls. The lighting system consisted of candles set in pewter sticks and one little whale-oil lamp. A wonderful museum, but no place for modern life to go on in! What was comfort to our great-grandfathers is discomfort for us. And what was a cheap house in their day would be a costly house now, for it would take a great many trees to build a house like this one in Dedham.

It is estimated that there are now 3,250,000 "living units"—that is, places where single families make their homes—that do not come any nearer to the American standard of health and comfort than this old Dedham house does, and that during the next 10 years—with young people marrying and setting up new homes and old living places wearing out and being abandoned like old shoes—7,500,000 new dwelling units will be needed. Where are these 7,500,000 new living places to come from?

The Fairbanks House at Dedham, Mass.



Unrolling a Log

Just as the use of sawed boards and timbers made it possible to build a house with less wood than when it was built of whole logs, so the use of what is called "plywood" makes it possible to use still less of it than was needed to build a house of boards and joists and shingles. And since this house requires less wood, and also less labor to put it together, it costs less money.

The making of plywood is based on the old practice of making veneer; that is, of gluing thin sheets of wood together and using them as one piece. Veneer was used for furniture. It did not have to stand any heavy strain. It did not have to be cheap. But in order that plywood might be used for houses, it had to be both strong and cheap—far stronger and cheaper than veneer has ever been. Two things were necessary; a glue better than any known, and sheets of thin wood larger than the distance through a tree trunk. Both of these things we have now, and they were found in this way.

During the World War the Government had a sudden need for airplane propellers. These must be of wood that would not split or warp or break when spun at terrific speed. If pieces of a propeller should break off and fly into space there would be one valuable air pilot the less. For this reason the propeller blades must be made of thin layers of wood. The idea was right, but in order to apply it there was needed a glue stronger, more lasting than any known. The Forest Products Laboratory of the Forest Service was asked to find this glue. During their search for it they discovered one, practically waterproof, which is used in plywood. It looks like heavy, brown, half-transparent tissue paper. A sheet of it is laid between two thin layers of wood and made a part of them by the use of heavy pressure and heat, and it has such a grip that the wood itself will be torn apart before the glue will let go. Without this glue, houses of plywood would not be possible.

But neither would they be possible without the new methods of cutting the wide thin sheets of wood, frequently 6 feet wide, from trees with a diameter much less than this. To

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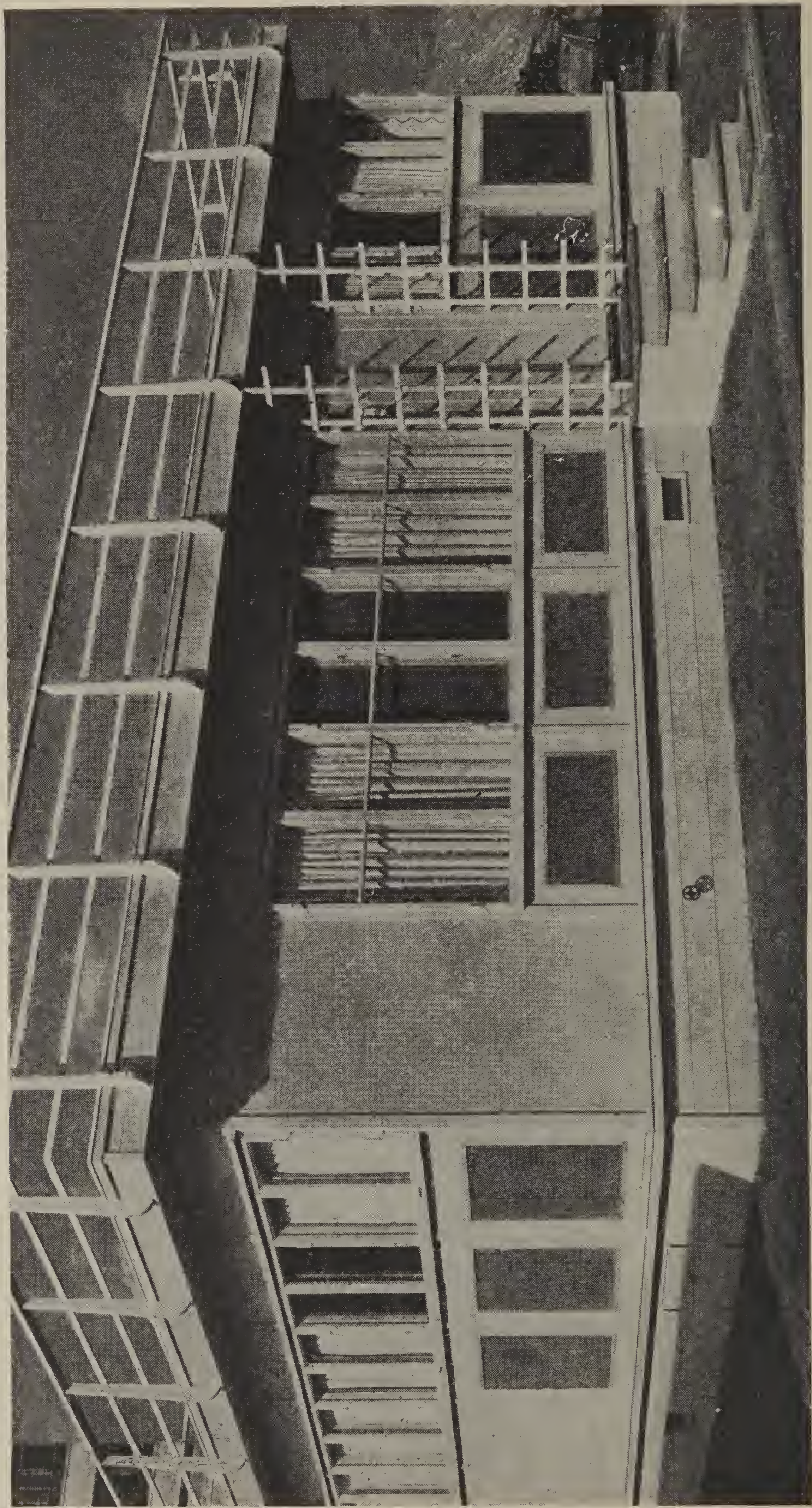


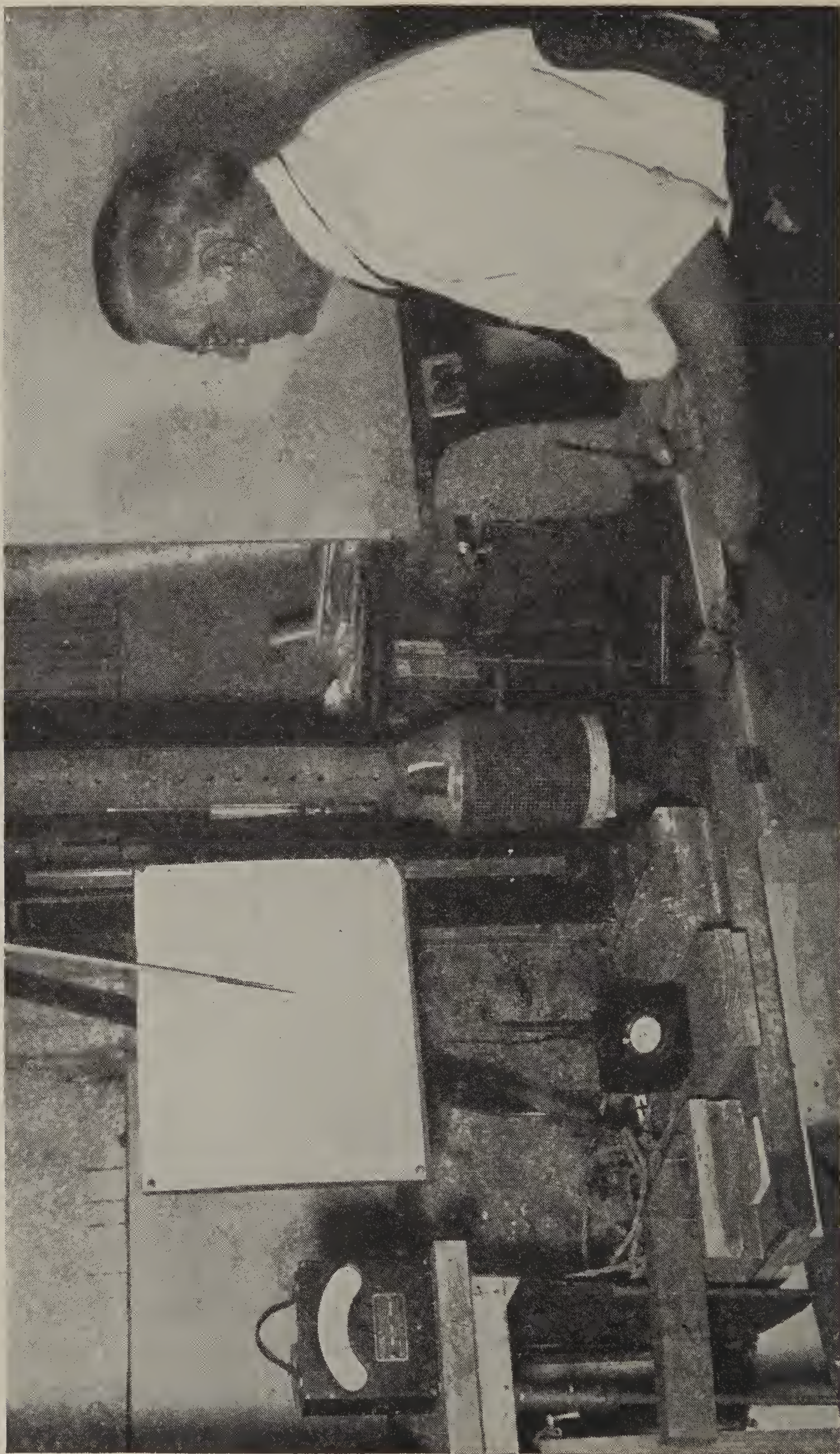
House of Plywood

get these, a log is stripped of its bark and soaked and steamed till it is somewhat softened. Then it is put into a machine something like a turning lathe and set revolving against a long knife which cuts a thin layer from it. Round and round it goes as though it were a bolt of silk being unrolled. Douglas fir is being unrolled in this way and used as the veneer of plywood. Upon the surface of a table or the side of a wall it makes a pattern of great beauty and of a rich golden color. No wallpaper, no plaster, no other covering is necessary.

Plywood is not used as ordinary boards are used in the building of houses. It is made into units of standard sizes, such as 8 by 4 feet. Each unit is made of two layers of plywood, one glued to each side of an internal framework with an air space between—seasoned so that it will not warp or shrink, glued so that it will not split, made to interlock along the edge with the next unit, and forming both the inside and outside surface of the wall of the house.

Other units have been developed which will make both the ceiling of one room and the floor of the one above. The surfaces of these plywood units can be of any sort of lovely wood veneer, with any sort of beautiful finish. All the other units of house building that can be made of wood have been worked out in standard sizes, and of them has been built by the Forest Products Laboratory in Madison, Wis., a model house of five rooms, which can be set up by seven men in 21 hours. This is a charming house, a livable house, a house easy to operate, and easy for the breadwinner to pay for, and built of far fewer trees than the houses of our great-grandfathers. It is part of the answer to the question of how 127,000,000 people can get all the wood they need from 630,000,000 acres of forest land.

But that house has still the final and greatest drawback to the use of wood—it is not fireproof. However, scientists have solved many harder problems than fireproofing wood. In the Forest Products Laboratory is a long room full of intent men turning flame upon wood which has been soaked in chemicals or coated with metallic paint. They raise the heat and lower it to see just how high a temperature it will



Testing Wood for Fire

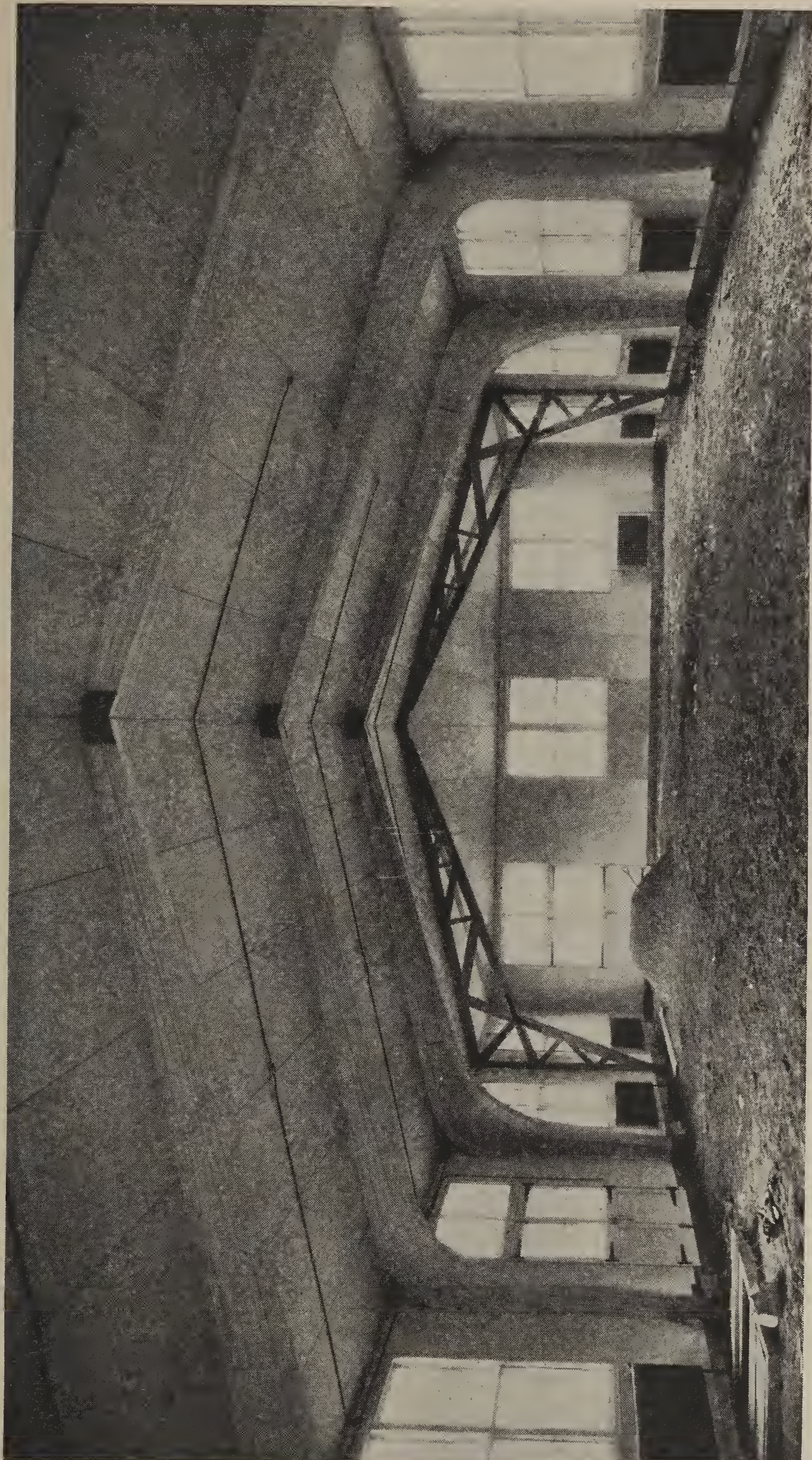
stand; they blow air upon it in imitation of a high wind; they cool it to find out how long it will hold enough heat to set fire to whatever it touches; and they test it as they tested the strength of glue, over and over again, and write down just what has happened to each stick of wood. They hang these tested woods in long rows, each one carefully labeled with the name of the wood, what was done to make it fireproof, how much heat was applied to it and for how long; and the result—whether it actually caught fire or merely rose in blisters or charred. They have not yet found the perfect way to fireproof wood.

There are several forms in which small sections of wood are built into larger units and used as one piece—the old veneer, the newer plywood, and laminated wood are among them. These are used in different ways for different purposes, but the underlying idea is the same in all. In places plywood can even be used as a substitute for steel.

The great beams of wood, each one the trunk of a huge tree, which were all that our ancestors had to hold up their roofs, will splinter and break under heavy weight. Steel beams are not only stronger than a tree trunk; but also they can be made longer than any tree could grow. Steel girders will not crack or break under far heavier loads than a solid beam of wood will bear. We could not have our great skyscrapers nor our long bridges without steel beams. But laminated wood of thin sheets, plywood, or smaller beams overlapping, are much stronger than single beams. Just how strong can they be made? Just how far can they take the place of steel?

The Forest Products Laboratory has a vast, terrifying machine that lays hold of a great arch made of wood which has been centuries growing and begins to put torturing strains upon it. The pressure becomes fiercer, increasing pound by pound to 1,000,000 pounds if the arch can withstand as much pressure as that before it splinters and breaks. But this metal monster is as much a safety device as chains on an automobile tire, or the guard over a buzz saw, for under this testing and retesting it has been found that the arches and beams made up of layers of wood glued together under

A Million Pounds Pressure Can Be Put Upon the Arch



Arches of Wood Can Take the Place of Steel

pressure can be put to some of the uses that solid wood is not strong enough for.

A great storehouse of the Forest Products Laboratory is spanned by arches of this laminated wood which have been treated with a protective finish that gives them a luminous glow, as though one could look down through the surface of the wood into the heart of it. Arches like these are light, comparatively cheap, and for certain uses have their advantages.

And there can always be plenty of wood arches—so long as we take the trouble to grow trees!

WOOD PULP

To make wood useful to himself, man always has to take it apart and put it together again in some other shape. A tree, left to itself, will not do much for him except to offer shade, a little shelter from the rain, a refuge, and possibly food. A tree cut into large pieces with saws or axes or knives can be reassembled into houses or boats or carriages. But wood taken apart by grinding, wood dissected into the smallest particles which are still wood—wood that has been "pulped"—can be put together in a far greater number of shapes for a far wider use.

If you ask your grandmother what she did her sums on in school she will answer, "a slate." This was not because we did not know how to make paper when she was a girl, but because we did not know how to make it out of wood. The art of paper making is so old that we do not know when or where it began. It came to us from the Chinese, but the Chinese learned many of their arts from the people of India, who began to live in cities and manufacture cloth so long ago that the historians have no date for it. That early paper was made of rags—of the fibers that grow in flax or cotton, sometimes even of silk fibers—used first in cloth, and then as a second use, made into paper. In the early days of our country the paper mills advertised for rags, and when they did not get them they had to stop running. Not until we learned from the wasp, who has made his nest from paper as long as he has been on earth, that paper could be made from wood, did we have all the paper we needed. We had to learn to do what the wasp does—to pulp wood.

This is, roughly speaking, to continue the process of dividing it up. There are two ways of doing this. One is to cook the wood in water in which a little caustic soda or acid has been added. This separates the wood fibers without breaking them and is used in making the strongest paper. The other way is to put wood chips into a grinder—a sort of glorified extension of a coffee mill. This mill grinds so effectively and so exceedingly fine that the mere friction makes the pulp too hot to touch. It comes from this grinder a grayish substance,

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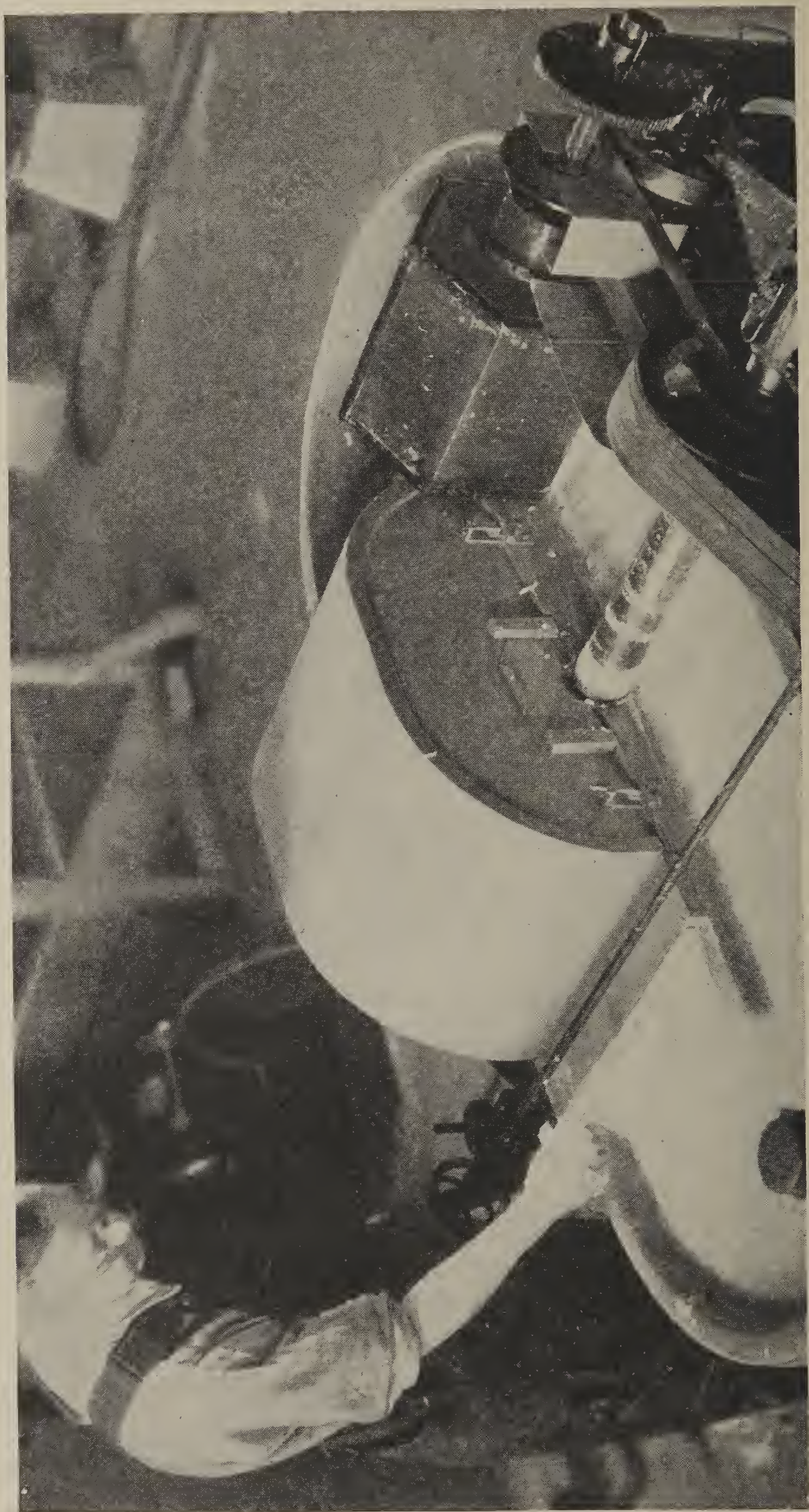


Pulping Wood

moist and sticky like bread dough with too much flour in it.

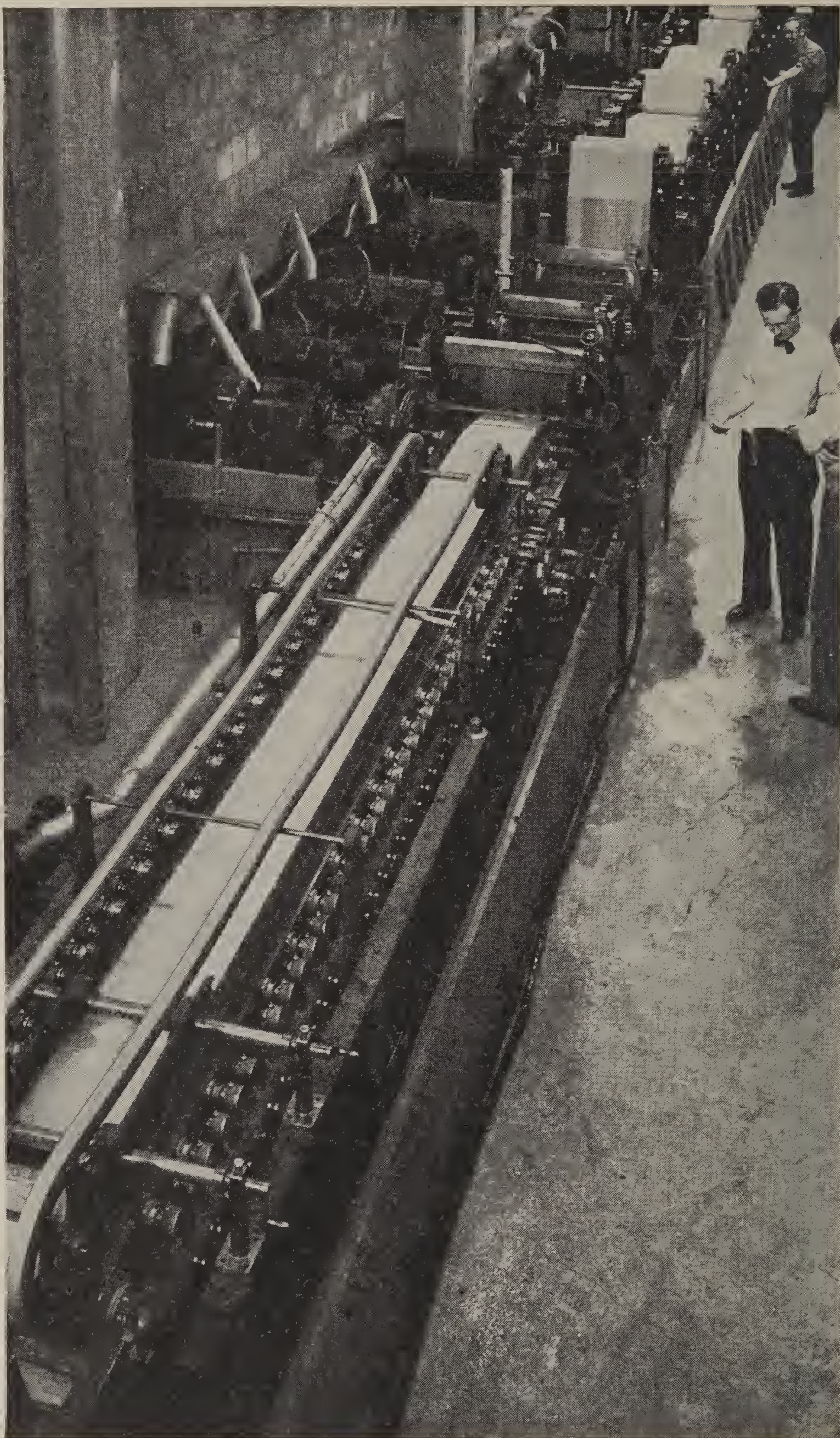
The pulp can be put back into solid form because wood is composed of cells, most of which are shaped like slender fibers, and the walls of these cells are made up of smaller threadlike bodies called "fibrils"; the fibrils are formed of infinitesimal spindle-shaped bodies. Wood is composed of short tiny threads within threads. They can be made to stick together again in the same way that felt is made from rabbits' hairs.

In the modern process of making paper, wood pulp made by either of these processes is mixed with water till it looks like skim milk, beaten like an egg, and then in a slow stream floated out above a moving belt of cloth or fine wire mesh through which, as it moves on and on, the liquid drains away, leaving a thin layer of wet pulp like undissolved sugar in the bottom of a cup. The belt passes between steel rollers, as clothes are put through a wringer, and more water is squeezed out. It goes on between hot rollers as sheets go through a hot mangle, and the water that has not been wrung out is steamed out. On and on it goes between more rollers that squeeze it and dry it and polish it, and finally, if it is news-print paper, as most of it is, it is rolled up and sent to the printers. Paper is a tangled mass of wood fibers—it is felted wood.

If it is true that we Americans are great and civilized and happy because we can read, that we are a democracy because we have a free press, and that we have a wide culture because we grow up in the presence of books, it is because we live in a land of plentiful forests. We live and grow, intellectually speaking, on a diet of wood pulp, and wood pulp is a forest product.

Wood pulp is used for many things besides paper—millions of tons every year are made into paperboard for wall coverings which might otherwise be made of larger boards, into boxes and containers and other things, which would certainly be made of wood as it comes from the tree, if paper had not been invented.

The use of wood in the form of pulp has all come since our



Making Paper

grandfathers' time. In 1865 none of it was made in the United States. Thirteen million tons were pulped in 1930. This is a vast amount of wood, but it is not necessarily the wood that makes good boards or even the wood that makes good plywood—almost any part of a tree will make wood pulp.

Most of our paper is made from spruce, fir, and hemlock, a little from birch and beech. We could grow crops of these trees that would give us all the paper we need year after year after year, just as we grow all the potatoes we need and all the apples, but we have not begun to do it yet, and every year we bring in pulpwood from Canada, and many ship loads from Norway, Sweden, Finland, and some from the Union of Soviet Socialist Republics.

Another way of taking wood apart without changing its nature is to explode it. Chips are fed into an explosive chamber or "gun", tightly closed in, and steam at 350 pounds pressure turned upon them which—on the same principle as a pressure cooker on the kitchen stove—sends the temperature up to 375° F. for about half a minute. Then for 5 seconds the steam pressure is raised to 1,000 pounds, and the temperature goes up to 540°. All the moisture inside those chips of wood is so hot that it would become gas but for the terrific pressure which prevents its expanding. Then the lower part of the gun opens, the chips drop out, the pressure upon them is suddenly removed, and the water expands instantly into gas, ripping the wood into the fibers of which it is made.

But the fibers are of the same substance as the log, or the shingle or the sawdust—they are wood—and they too are felted into boards as wool is felted into hats. The wide sheets which are made from them are as truly wood as though they were cut from the heart of a 400-year-old pine.

Pulling off the Bark for Tanning Leather

TREES FOR TANNING

Not everything that the forest gives us is wood. As a forest has inside it a variety of valuable living things, so a tree has inside it a variety of useful substances.

So far as we know the skins of animals were man's first clothing. When the last great ice age was coming on, when year after year the glaciers were nearer and the wind that blew over them was colder, when the sequoias and magnolias were being frozen and scraped off by the thick sheets of ice that plowed deep furrows into the rocks in New York and Ohio, Indiana, Michigan, Wisconsin, and Minnesota, then the men who were living in what is now our country probably picked up the hides of the animals they had killed and put them between their own shivering skins and the weather. When they had run barefoot over frozen ground till their feet were bruised, they tied a piece of animal hide over the soles of their feet. It was a matter of deep regret when a specially warm and comfortable wolverine skin dropped to pieces, or a well-fitting sandal rotted away.

Just when or where men learned to tan skins so that they would last and stay soft and pliable, no one knows. It might have happened when some shallow-rooted hemlock had blown over and the trunk lay soaking in a forest pool. A brown hairy hunter who had killed a squirrel for his dinner, skinned it, tossed the worthless little hide into the water beside the rotting hemlock trunk, and went home to his cave above a stream. Following along the same forest trail months after, he saw something floating in the dark pool and pulled it out. It was the shape of the old squirrel skin he had thrown away, but soft and light. Moreover, it was all there—none of it had rotted away as skins had when he threw them on the forest floor. He carried it away with him. What had made the difference? Was it the dark pool below the hemlock trunk that the little skin had fallen into? Would the same thing happen to a larger skin if he dropped it in the same place? He was not much used to thinking, but he tried hard to understand, and when he had killed a young deer he carried the skin to the same pool and dropped it in in order to find out—

and that aromatic substance called tannin in the bark of such trees as hemlock and oak, which had soaked out of the fallen tree, soaked into the deer skin, and the prehistoric hunter had discovered a crude way of changing raw hides into leather.

We still use tree bark in tanning leather. Probably the bark of the same sort of trees that early men used—the oak and the hemlock—since these trees have been on earth longer than man has. The modern methods of tanning skins are much like the one prehistoric man worked out, only instead of tanning one skin at a time after he had killed the animal that grew it, and doing the kneading and stretching by hand, and taking perhaps months for the job—we bring together skins from all over the world, and tan them by the thousands with machines to do the heavy work. And if there is a sudden demand for leather—as there was during the World War when our soldiers had to have shoes—we not only bring in bullock hides from South Africa, but also so speed up the process of tanning that what had once taken months to do can be finished in days.

By the help of trees our remote great-grandfathers preserved their coats and shoes of skins. By the help of our forests our soldiers were well shod. By the help of trees we wear leather shoes today.

To take the bark from an oak or a hemlock in order to get the tannin it contains, of course kills the tree, but there are very valuable things inside trees which we can get without cutting them down, or chopping them up. There is, for example, so delectable a thing as maple sugar. Early in the spring in the hard-maple country—possibly on a warm February day, certainly by March—some farmer's boy, feeling the sun warm on his back and seeing tiny streams creeping from under the glistening edges of the old snowdrifts, fingers the jackknife in his pants' pocket, and starts for the wood lot. The bark of the sugar maple is not thick, and before long he comes back on the trot.

"Sap's running!"

Then the farm force mobilizes. It gathers its buckets and its spigots, tugs out the big kettle, and hurries through the melting snow to catch that first run of faintly sweet sap which is carrying the sugar that has been stored all winter below ground, up through the trunk to give the tree a quick get-away in the growing race of the spring. The work must be rushed because the first runs of sap make the best-flavored sirup. The kettle is swung up, a fire built beneath, and the pails of sap emptied into the kettle as fast as they fill. The process of making the sugar is the simple one of keeping the kettle boiling till enough of the water has gone off in steam so that the sirup which is left will crystallize. The only real point for anxiety is that moment when the sirup is undecided whether to burn into charcoal or crystallize into sugar.

The making of maple sugar has expanded, just as the making of butter has, from a thing that every farmer who owned a sugar bush did in the spring, to a large business operated by specialists with special equipment, but the process is essentially the same old one that the early Americans used.

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"Sap's Running"

From inside the living tree we get another liquid which has been important to man for thousands of years. This is oleoresin. In the United States we use it in the form of turpentine and rosin, and call them *naval stores*—probably, because when our young country built its ships of wood, turpentine and rosin were used to make them watertight.

This oleoresin serves a strange purpose in the conifers from which it comes. Of all these, the longleaf pine produces the most oleoresin with the slash pine a close second. The longleaf pine grows only in a warm, moist, even climate. It is a tree very fussy about climate but extremely easy about soil—sand or loam, moist or dry, even clay, are all the same to the longleaf pine. It has found a region to suit itself extending from the lower corner of Virginia, down through North Carolina, South Carolina, Georgia, and Florida, around through Alabama and Mississippi and over beyond the river into Louisiana and Texas. At the northern edge of this region the longleaf pine has 200 days without frost in which to grow, and at the southern edge about 100 more. In March the winds blow up from the Gulf of Mexico heavy with warm rain and keep on bringing moisture until September, when they swing about and blow in from the cooler Atlantic until December. Then they shift and veer undecidedly until March comes again. During the time that they blow in from the Gulf and the Atlantic, they bring from 48 to 62 inches of rain—all that a tree needs.

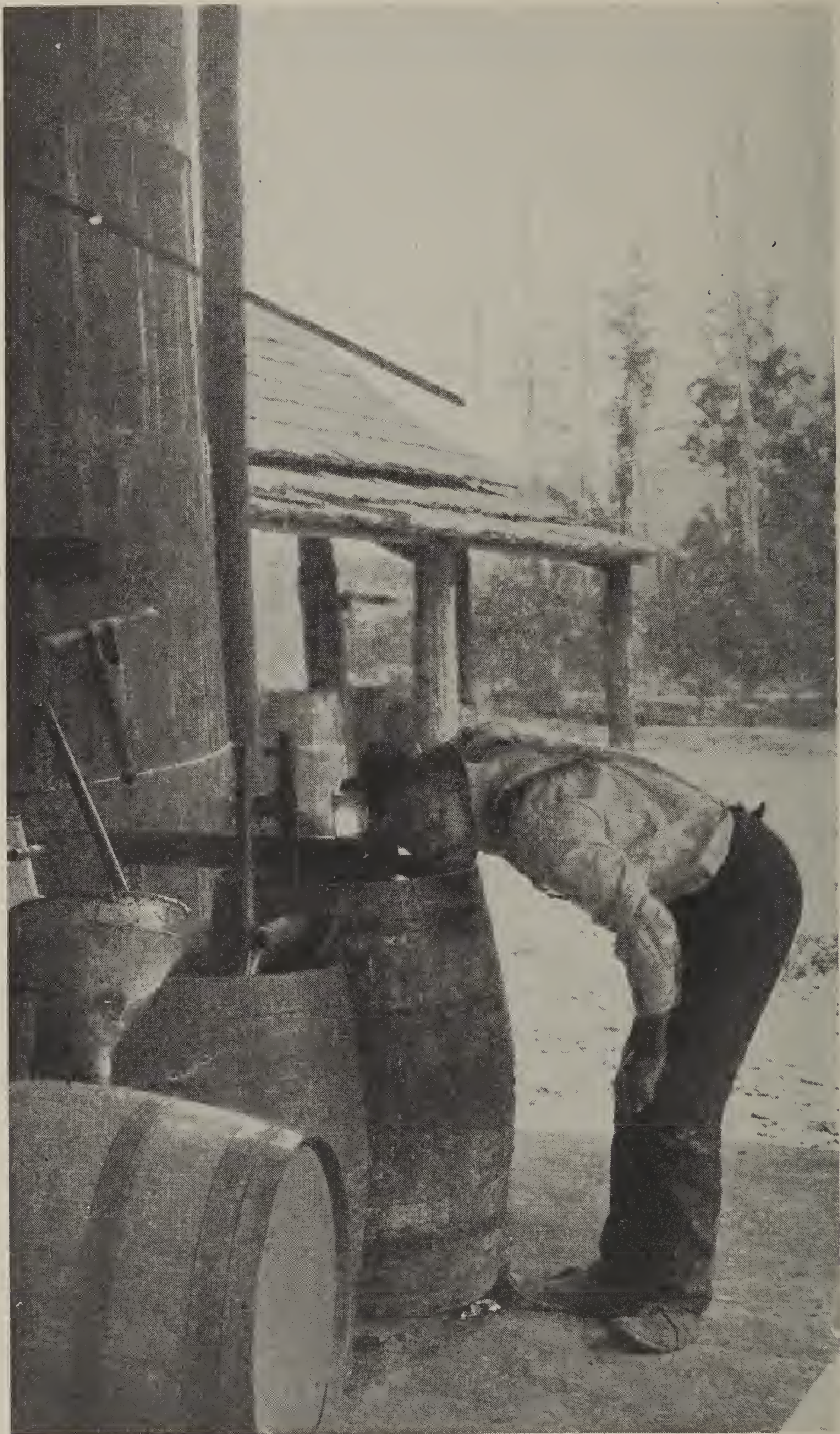
It is necessary to know something about the structure of these resin-producing trees in order to understand how they can give us oleoresin, just as it is necessary to know the structure of a bird's wing in order to understand how it can fly. As in other trees, there is the column of dead heartwood at the center, and a layer of sapwood around it through which the sap travels to the leaves. Outside the sapwood is a thin layer of new living cells called the cambium. These cells have thin, soft walls, and they grow with remarkable speed—dividing and redividing—increasing on the inside to make new sapwood and on the outside to make more bark.

Chipping

So far such trees as the longleaf pine and slash pine are built on the same plan as all other trees. But they have, in addition, tiny pipes surrounded by living cells, and these extend up and down through the tree and back and forth horizontally within it, so that there is a sort of plumbing system, a network of interconnecting pipes. The cells of which these pipes are built exude soft gum—the oleoresin. Now the use the tree makes of this gum, which is soft enough to flow through the slender pipes, is to heal its own injuries. The pipes are in a sense military roads like those the Romans built in Britain, like the top of the Great Wall of China, like the ones the Italians laid down in Ethiopia. Along them rushes the oleoresin to repel attack. Through the pipes and out to the surface of the tree it flows when a cut is made through the bark into the living wood beneath. In 5 minutes after the ends of the resin pipes have been cut, tiny drops ooze out and spread over the wound, hardening as the air strikes them and forming something which is like the new skin that grows over a cut in the hand. It is this healing cover with which the tree tries to stanch its wounds, that we take away to use, and in order to get it we wound the tree again and again—cut through the ends of the pipes higher and higher up by a process that is called "chipping."

Every week during the growing time of the tree which is the time when the warm wet winds are blowing in, gangs of men go through the forests of the pines and cut fresh wounds just above those which the trees have been so desperately trying to heal. How word of these repeated attacks is carried through the tree, we do not know. No internal telegraph system has been discovered, but the beleaguered tree puts in more and more resin pipes—military highways—leading from above down to the point of attack. Sometimes these roads extend 20 feet above the chipped face. Through them the tree sends fresh oleoresin as fast as the cells can create it, and when this pours out at the newly scarred surface, we set metal troughs to lead it into pails, gather it up, and carry it away.

But what do we do with this oleoresin? It is not the



The "Stiller"

thick, sticky molasseslike stuff which the workmen haul away through the pine woods that we want, but the two chief things which it contains—turpentine and rosin.

Somewhere out in the woods is a copper still. It stands under a shed open at the sides. Into the boiler the men pour some 15 barrels of oleoresin at a time, leave it in charge of a man called the "stiller", and go back for more.

This stiller has an uncertain job, for he must regulate the whole process of distillation not by thermometers or time clocks, but as a man tunes a piano—by ear. Inside the boiler the heat is beginning to change the turpentine into a gas, and it bubbles out of the heavy rosin as steam out of boiling water; as a gas it is led away through a long spiral pipe called a "worm", down under water and gradually cooled till it becomes a liquid again. As the turpentine is led off, the stiller listens near the lower end of the worm to tell what to do next.

There is a danger point when he hears a tumultuous gurgling from his listening post and knows that his brew is likely to froth over. To stop it, the bubbles in the rosin must be broken as one breaks the bubbles in a coffeepot by quick stirring. But the stiller cannot get at the mixture to stir it, so he rushes the fire to make the rosin so thin that the bubbles will break of themselves.

After the fire is once lit under the still, it is kept up day and night. All day the heavy smoke rolls through the forest; all night the flames shoot up. When all the turpentine of one boiling has been led away through the worm, and the rosin allowed to flow out into a tank, a fresh supply of oleoresin is poured into the boiler, and the men pile up the fire.

We sail the seas these days in ships of steel. What do we use these naval stores for?

The greater part of turpentine finds its way into paints and varnishes; that is, it is one of the chief things used to preserve wood from the effects of the weather, from fungi, from disease. It performs for other wood very much the same function that it was intended for by the tree that grew it. It is used in the printing of cloth to keep the colors from running

together. From it is derived in small quantities and at a high cost a substance much like camphor. And in the making of rubber, turpentine is used as a solvent. Yes, turpentine is a good gift.

Rosin too is used in the making of quick-drying paints and enamels and the colors used in firing pottery. And it is used as size for writing and printing papers so that they will take ink. Mixed with a little turpentine, it is used to coat the insides of beer barrels as the ancient Greeks coated their wine jars with pitch. It can be divided further into gases and oils. One of the oils will burn like kerosene; others are used in printers' ink; the heaviest in wagon grease.

Rosin, too, is an important gift from the forest.

We have learned how to get turpentine from trees without killing them—how to chip them for 10 or 15 years and leave them in such good condition that they can be used for lumber. We have learned also how to get more oleoresin from fewer trees for a longer time than we once did, and this is the same as saying that we get more of it from smaller forests.

WHAT IS WOOD?

When some man, picking up the branch of a tree, began to wonder what it was made of, he had got a long, long way from the savage state. He must have realized the great difference between what happened to wood when he chopped it up, or sawed it up, after which it was still wood; and what happened when he set fire to it and it became flame, smoke, and ashes—none of which was at all like what it had been before. He was a modern-minded man, and he opened a door to high adventure which scientists are still pursuing. For years now they have been conducting an exploring expedition as exciting as the one Roy Chapman Andrews led into the Gobi Desert, only it is made with retorts and electric current, instead of camels and motortrucks, and is headed toward a far more remote land than Tibet, a land which is beyond any to be reached through the microscope—that far realm of the atom and the molecule which is hidden in the very structure of wood. To reach this land they are taking wood apart, not with ax or saw or grinding machine or explosive gun, but with chemicals which divide it as no machine on earth can.

These chemist explorers have succeeded in obtaining from wood a large number of substances among which are several sugars, ethyl alcohol, analine used in dyes, furfural, molding powder and, most important of all, cellulose. Cellulose is a material long used in the manufacture of paper. Its field of usefulness seems almost unlimited.

When cellulose is captured by the exploring chemists it is seen to be soft and white like cotton but with particles so much smaller that they feel like grains between the finger and thumb. The discovery of cellulose was part of the answer to the man who first held a stick of wood in his hand and asked himself what it was made of.

The question naturally followed, in what form could this cellulose be put together again and for what could it be used?

There are already more answers to this question than there are leaves to this book—and we have not got them all.

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Cellulose, if it had a sign to represent it as the eagle represents our country, might be shown as a horn of plenty—so many things of so many sorts can come out of it. There are guncotton, which is a powerful explosive; smokeless powder; food for cattle. Shoe soles are made from it; poker chips, lemonade straws, long-wearing rugs and carpets, and upholstery goods; materials to cover roofs and walls; substitutes for cotton batting; bags and purses of a leather substitute which no animal ever wore under his fur; lacquers that come from no oriental insect; a waterproof, fireproof, acidproof substance with a high gloss which may be used for anything from telephone receivers to salad bowls.

Besides these, there is a group of things which are produced because it is possible to reduce cellulose to a jelly. The processes by which these things are made, the chemicals that are used, the machines which handle them, all these are as different as can be, but at some stage in their manufacture each one of this group of things is a jelly.

Take for instance Cellophane—as clear as glass, waterproof and dustproof, as pliable as paper and far stronger and more durable. Nothing so perfect has yet been discovered to wrap food in, to protect delicate merchandise, and quite recently as a cheap, unbreakable substitute for window glass.

What can't you make of a jelly which will grow hard and still have a luster like pearl or glass or silk! Just as the wasp showed us how to make paper out of wood, so the silkworm has taught us how to make out of cellulose that soft, glossy, beautiful thread, rayon.

A Frenchman named Chardonnait, who watched the silkworm at work, learned from her how to make rayon. He found how, inside that chemical laboratory which is her body, the worm transforms digested mulberry leaves into a sticky jelly and forces it out through tiny holes called spinnerettes, and how this hardens into slender shining threads.

In making rayon, wood pulp instead of mulberry leaves is converted into an orange-colored jelly, like heavy molasses. It is forced through a platinum nozzle with 40 holes, each 0.002 inch in diameter, into a shining thread. This thread is

washed in a spray of warm water, dried in a wind of warm air, wound on bobbins, bleached, and sent to the textile mills to be woven into beautiful cloth. It gives us a fabric that is quite as lovely as silk for as little as we pay for cotton. Just as to make houses out of plywood makes it possible for more of us to have homes of our own, and making paper out of wood makes it possible for all of us to have books, so making rayon out of wood makes shining garments possible for us all.

There can be only as much silk as there are worms to spin it, but there can be as much rayon as we will grow trees from which to make it.

Out of that cellulose jelly is made those long narrow ribbons, those semitransparent bands on which are recorded history as it is being made day by day, the great romances of the past, the quite different dramas of the present, the discoveries of inventors and the great adventures of scientists—the films on which motion pictures are taken. We cannot all go into the Antarctic, but we can see Byrd's airplanes landing there; we can see Picard's gondola go up into the stratosphere and watch Beebe's bathysphere dip down into the sea. We can watch the human heart send the blood pulsing through the arteries. We can watch a malaria germ catch and destroy a red blood corpuscle; we can travel with our eyes to more parts of our world than we could take our bodies to in 80 years of constant traveling, and it seems probable that we will soon be able to look at what happened 50,000,000 years ago to the suns that circle round the shores of the Milky Way—and all because of these films made from that jelly made from cellulose, made from wood grown by the forests.

To have plenty of forests is to have plenty of books and unbreakable windows, and plenty of glistening cloth, and the delight of the moving pictures.

Those scientist-adventurers who have blasted their way into the very composition of wood by a chemical barrage far more destructive than any machine gun could lay down, have found many things beside cellulose. Among them is a

strange dull-colored substance which makes up almost one-third the weight of wood. They can look at it and touch it, but until recently they could not tell what it was or what it could do. They call it "lignin."

For 25 years men have been trying to find a use for lignin, as they once tried to find a use for anthracite which they didn't know would burn. Lignin comes, they know, from the cell walls and the spaces between them. Apparently it gives the cells strength and hardness.

Somewhere in that unexplored jungle, which scientists enter when they take wood apart by chemical means, the scientists knew was the knowledge they needed to make lignin useful. In their search for this knowledge they got down to the actual structure of the lignin molecule and found, quite recently, that the elements of carbon, hydrogen, and oxygen which compose it, are hooked together in a five-sided molecular structure called the "furane ring", and not in the six-sided hydrocarbon ring as they had supposed. This gives the chemists a new place to start from. Already they have found that there are ways to compress lignin into wallboards and floor tiles, ways to get dyestuff from it, and acid for bleaching clothes, and a substance which will act as a binder for roads, and another that can be fed to cattle. The door to the uses of lignin has been opened just a crack. Sometime the chemists will swing it wide.

To look at a forest—banks of solid green branches against the sky, undergrowth of ferns and mosses and shrubs, animals stealing in and out, birds and insects, clear streams—is to look at a storehouse full of the things we need to make us happy and prosperous. But it is also to look at a tireless and able servant who gives us the help we could get from nothing else.

That wise farmer who left his south 40 acres in forest knew not only what the wood lot would give him but also what it would do. He realized that the topsoil on the sloping field below it was richer and deeper than on the other hillsides so that the field always bore a good crop. He saw that even when there was a heavy downpour not enough water rushed from the wood lot across the lower field to carry the soil away with it. He saw, too, that the little brook that stole out from under the trees was always clear because the roots held the soil so firmly in place that it could not wash away; that even in the spring it never rose into a destructive freshet because the snow under the trees melted slowly and held the water back so that there was some water in that brook all summer long. And when he walked along beside the eastern edge of his small forest he did not feel the hard west wind that so often flattened out the crops on his other fields, for the mass of trees, many of them old pines and oaks, a hundred feet high, which stood directly across the path of the hot dry winds, left a quiet space for young grain to grow in.

Without that friendly forest, what would become of his land? Just what has happened to millions of acres of our land which have no protection from water or from wind.

When we Americans look across the great country which is ours we see many streams that do not run clear, and rivers like the Missouri and the Tennessee which are always thick and brown because they are freighting away as much of our soil as they can carry.

If an army of men came marching to take the land from us, what would we do? We would send out an alarm like the one that Paul Revere carried during the Revolution, but it would go faster than any man on horseback could carry it. All up and down the valley the radios would say:

"The soldiers are coming to seize your land!"

Every telephone bell would ring furiously, and a voice would say:

"Hullo—hullo! An army is coming to take your land!"

Women would run out of their houses and call to their husbands at work:

"They are coming to take away our land!"

Airplanes would fly back and forth dropping leaflets saying: "Men are coming to steal away your land!"

The same words would be in large black type on the front pages of the newspapers and on placards at the courthouse in every county seat. Every preacher would announce it from the pulpit; every school teacher would tell the children.

Where the telephone lines did not reach, men would speed along the roads with the news in automobiles, and where the roads were too poor for cars, they would climb upon their farm horses and kick them into a trot and then into a heavy gallop till everyone knew that an army of men was coming to take their land.

We know what they would do. Each man would drop his work and take a gun if he had one, or the old sword that his grandfather had worn in the Civil War, or if he had nothing but an ax, he would catch that up and hurry to the nearest village where the men were gathering to fight the army coming to take away their land.

Our land is being taken away as no human enemy could steal it. It is being lifted up and carried off.

A. Shoestring Erosion. B. Gullying

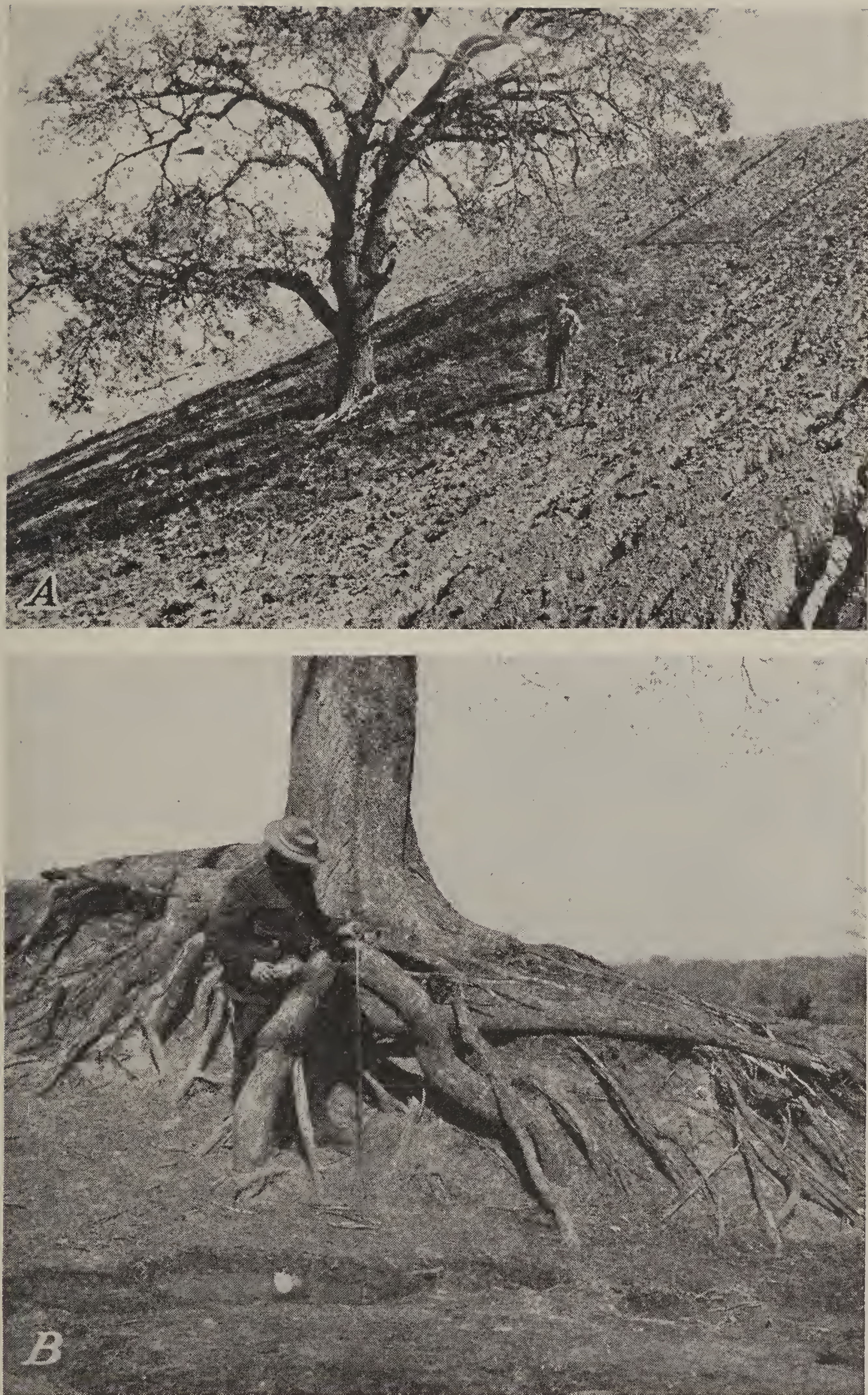
Ever since the world was, water and wind have been wearing the rocks into sand and rearranging the sand to suit themselves—piling it up, smoothing it out, throwing it into the sea. Until the land had the help of plants, it had a hard time to keep its head above water.

The rain falling along the sides of a valley starts to run slowly downhill in a thin sheet. If there is nothing to hold the soil in place, no armor to protect it, the film of water which flows down over bare ground, or ground planted to such crops as corn, cotton, and tobacco, which must have clear spaces between their rows, brings some of the topsoil with it. This is called "sheet erosion." If this is allowed to continue, the water digs narrow channels into the earth, gathers into tiny swift rivulets, picks up the soil, and arrives at the bottom of the hill thick with mud. The rivulets look like shoestrings, and this stage is called "shoestring erosion." And if this goes on, the rivulets join together, gouge out deep beds for themselves, and rush along with a heavy load of soil and sand to deposit in the nearest stream. This is called "gullying" and it is the last, most destructive form of erosion.

It is estimated that the Mississippi River alone carries 400 million tons of soil into the Gulf of Mexico every year. Erosion of the soil by water in the Mississippi Valley is an example of erosion elsewhere. For the entire country, estimates indicate that 100 million acres that were once good farm land are gone, and we can never get them back again; that 125 million acres have been badly injured and another 100 million are seriously threatened.

It is at this point that we ask the help of forests. As the treetops will hold back the wind, so the roots will hold back the soil. They will weave a net underground as the branches will weave one in the air.

If you examine the root systems of trees you will understand how they can anchor the soil. From the point where the tree seed sprouts, a tiny root starts down; but it has not grown more than an inch before it sends out along its sides little rootlets which work out into the soil. In their search for food and water, these rootlets go through the ground like threads drawn by a needle. They curve around the under-



A. Tree Roots Hold the Soil. B. Roots of the Elm

ground rocks, they search out the underground streams, they twist themsleves into crevices between the rock strata, they weave themselves into a thick mesh underground, a heavy crumpled lace net from the surface of the soil down as deep as the water table if they can reach it, and in this net the soil is held. If you find a place where a bank of earth has been cut through, you will see everywhere near the surface the ends of the root threads holding the topsoil. If you look across an eroded field with a few trees still in it, you will see inside the circle held by their roots, the soil still in place, and probably grass still growing there. If you find some washed-out gully, you may see a part of its edge held firm by the interwoven roots of trees as a darn holds the heel of a sock. And perhaps you will find high above a washed-out ravine a great tree left holding the earth beneath it so firmly that neither wind nor water can steal it away. Trees everywhere, under every handicap, are trying to hold the land for us. There is nothing that will protect the land on steep slopes against erosion like a forest cover.

The forests can help us against the floods which are doing such terrible damage along our river valleys, in much the same way that they help us against that greater danger, erosion. Floods are more dramatic than erosion, because a flood, like a charge of cavalry, does all its damage in a short time, while erosion just keeps gnawing away year after year like a malarial fever. Forests cannot prevent the winds from bringing in the rain clouds and pouring the water in torrents upon the land, but they can help the land to receive it with very little damage.

To understand just how forests can do this, it is necessary to reason back from a flood to what caused it.

In the summer of a flood year the Mississippi River down near its mouth, is a menacing gray monster swinging sullenly from side to side against the levees that hold it. It does terrible work that nothing can stop. There are many things in that river besides water. It is heavy with soil and no more transparent than a plowed field. Strange things bob up and go under again—things which once belonged to people up the river—boards from their houses, rails from their fences, tables from their parlors, cows and pigs and chickens from their barnyards. All these are the wreckage from a great battle which the water has won in that long war between it and the land that has been going on since the Laurentian hills—the first rocks of this continent—pushed up out of the sea.

The result of this battle is not only a defeat for the land, but it is also a defeat for the American people, which leaves them poorer, and more unhappy, and far more discouraged than they have been before.

Why has this battle been lost?

This is what happened in one flood year: After a winter with more snow than usual in northern Minnesota—snow that had been blown into gullies and drifted into hollows in the bare lands from which the forests had been cut—there came, very early in March, a thaw. It began to rain steadily and hard, and the ice in the little lakes—Cass Lake and Winnebegoshish and the rest—went soft and slushy. As the

ground was still frozen hard, the rain could not sink into it. Where it fell on cultivated fields it ran off in muddy streams between the stubble rows of last year's wheat; where it beat down on cut-over forest lands, it carved out gullies; but where it fell upon thick new forests or upon fine old ones, it found a cover of snow which the trees had kept from blowing away so that the land below was not deeply frozen, and the rain could sink in. The rains continued, and the water that ran off the hard ground made the brooks rise high as the ice that had bound them began to break. So many of these streams had emptied into the Mississippi by the time it reached Minneapolis that it could splash high up at the bridges that span it and roar furiously through the deep channel where it turns the wheels of the great flour mills. It surged on past the turn where Red Wing is set in its circle of hills, which as yet showed no sign of green. But the Mississippi was not yet in flood.

Lower down, the Wisconsin River poured in the water it had gathered from the miles and miles of cut-over, burned-over lands where there were no trees to keep the heavy snow from running off in torrents. From the west, the Des Moines turned in the run-off from the rain-drenched prairie of Iowa, a slow stream from a nearly level land where the bogs had been drained, the ponds emptied, the streams straightened, whatever could hold back the water destroyed in order to put every inch of the rich prairie land under the plow. Farther down the Illinois came in from the east, usually a wide, obedient stream meandering through flat lands, but now so full that it stole over its banks. With all this load of water the Mississippi was high, the little bychannels and swamps along the way were full of water, the low marshy islands had disappeared; but the main channel is wide, and nowhere was the river over its banks. This was not yet a flood.

But far to the west in Wyoming and Montana where the rivers rise that flow into the Missouri—the Yellowstone, the Musselshell, the Powder River and the Big Horn—there had also been heavy rain, and the snow from the mountainsides and the steep rocky slopes, went off in freshets. In most

years the mouths of these rivers as well as the upper Missouri, into which they empty, would still be ice-bound, but this year there was a warm spell; the ice was ready to break under the rush of the water, and go down the Missouri with it—through the dry-farming region of North Dakota and South Dakota, through Nebraska and Missouri. Opposite the white cliffs of Alton this wide, slow, muddy river joined the Mississippi. The Mississippi struggled with this great volume of water. It took more room for itself where the land is low. It pushed hard against the levees, which tried to hold it in. It was full and savage, but yet there was no flood.

Slowly the Mississippi circled around one side of the peninsula which holds the city of Cairo, while along the other side rolled in the Ohio. If the water on this river had gone down the valley 10 days earlier, as it usually does, then the Mississippi could have carried all the water which poured into it at the point of the peninsula, and there would have been no flood. But up in New York State and western Pennsylvania there had been a late cold snap so that the heavy snow did not melt till thick clouds came to rake the hills and let down a curtain of rain. Then 2 weeks late the complaining brooks broke their ice and slid down over the frozen hillsides into the creeks that drained the farm lands, and the creeks rushed the water along to the Allegheny River, which carried the run-off to the Ohio, which rose out of its bed. All through Ohio and Pennsylvania and Indiana the spring had been held back, and the streams were now running full. The Ohio River rode high below Cincinnati, and as it neared its mouth, the Cumberland and the Tennessee joined it, straining full. So that instead of being a falling river at Cairo, the Ohio delivered to the Mississippi at the base of the peninsula more than 1,500,000 cubic feet of water every second. This is more than the Great River could carry within its banks. It had to have more room. The flood began!

On both sides of the river from there on levees are braced against the water like a man leaning against a door to hold it shut. The tops of the levees are higher than the land back

Courtesy, The National Geographic Society

The Levee Breaks!

of them, and against them the river rose inch by inch, foot by foot. There is a point beyond which no wall of earth can withstand the pressure of water. The river grew higher and where the top of a levee had crumbled, it reached in a thin trickle over the top. The trickle widened to a sliding sheet of water, the levee melted under it, and the real flood had come.

Usually it does not come—this flood—with a rush and a roar, before people in the lowlands have time to reach a safe place. When the early risers in the river towns find pools of yellow water where there was dry land the night before; when Main Street is not a dry road or even a muddy one, but a quiet shallow lake growing deeper and deeper, rising above the curb, over the sidewalks, seeping under the doors into the houses; then the people look for their old boats, for they know that the river has spilled onto the land and that a flood has come.

Farther south there were more and more breaks in the levees. Sometimes they began where a crayfish had burrowed and the water, driving through the tiny hole after it, had washed out a tunnel for itself; sometimes where a heavy rain had turned a levee into mud. Miles of continuous embankment held back the river from millions of acres on which the crops were now beginning to show green, and all along them thousands of men piled up sandbags and shoveled earth to keep them firm. All day they worked, and at night they planted torches along the levees and worked on. For this was a flood!

The water was only 2 feet from the top—18 inches—16. More sandbags! Shovel faster! Twelve inches from the top—10—and then, as with a careless push of a mighty shoulder, a whole section of the levee quivered, bent, was gone! There was no seeping, no gradual coming of water now. A wall of water toppled over upon the land. Houses and barns were lifted up from their foundations and floated away; there were beds and chairs and tables; there were horses and cattle; there were all the things that help to make people comfortable and prosperous, for this was a real flood.

Official photograph, U. S. Army Air Corps.

Flooded Town

A battle which the water had won! A defeat for the people who live beside the river!

And there was still another great body of water slowly pushing its way toward the Mississippi. Almost without a ripple the wide, shallow Arkansas turned in its waters. Fifty inches of rain on its headwaters that year, 52 inches near the mouth; cloudbursts on the bare, deforested heights of the Ozarks. More water than any other river, the Arkansas added to the flood. Still lower down the Red River poured in what it had gathered in Texas and Louisiana.

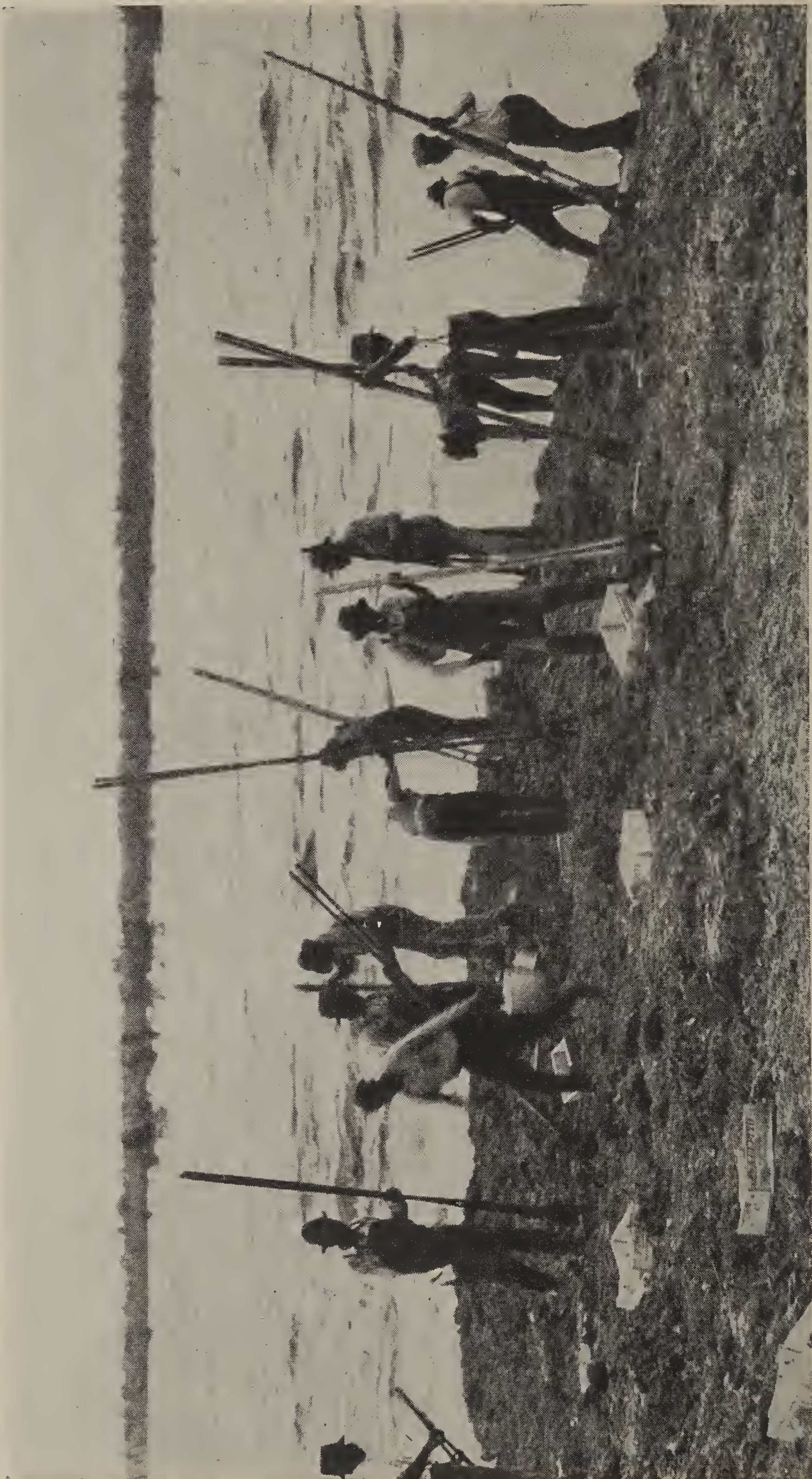
Straight in the path of the oncoming flood crest sat the city of New Orleans on land lower than the surface of the river. The levees surround it like the edge of a bowl. They had never broken yet, and there were thousands of sandbags ready to build them higher still. But 14 inches of rain had just fallen. Suppose this time the levees should *not* hold! The city was afraid. The flood came on.

On both sides of the city the land lies low and interlaced with streams and estuaries. It is good land on which to raise sugarcane and rice, and it is full of muskrats whose fur is a valuable crop. Levees hold the river back from this profitable land. Will they hold?

Above New Orleans levees had broken on both sides of the river, but in spite of all the water that had drained away through these gaps, the river continued to rise. A million sandbags had been piled along the rim of the bowl in which the city lies, but this time the river was going to take more land. All that men can do in the face of such a flood is to choose whether they will give it the city or the farm lands. Usually it is decided to offer the fields to the river. The levees are blown up, and the river takes the land of the muskrats, the rice, and the sugarcane instead of the city of New Orleans.

It is a great victory of the water over the land.

These great floods on the Mississippi do not come every year. Usually there is one only every 5 or 6 years when the snow melts and the rain falls at the exact time to bring the high waters on two or three of the main rivers into the



Courtesy, The National Geographic Society

Working on the Mississippi Levee

Mississippi at once. But when they come they destroy the homes and the crops of many people. Is there no way in which we can say to the river, "Stay where you belong!"?

Shall we say this to the river by building more levees? Stronger ones? Higher ones? We have found that when the Mississippi is in flood it pays very little attention to commands enforced only by levees. Already we have built 1,100 miles of levees on the Mississippi itself, and 180 miles on the Arkansas, and many miles on both the Ohio and the Missouri. We must keep them, and perhaps we must build more, but levees alone are not enough.

Perhaps the river will obey us if we give it more room of its own. We are trying that. We are sending dredges to scoop mud from the bottom and make the channel deeper. We have a machine which noses along the shallow places with a great flexible pipe and sucks out the sand. In some places instead of making the river deeper, we are making it wider. There is a plan to give the river more land opposite the city of Cairo and some just below the mouth of the Arkansas, and more still south of the Red River, where it can pour its water down through the Atchafalaya River into the Gulf by an extra mouth. All these are good plans, for there is no use trying to keep a large river in a small bed.

In some places we are holding the water back in reservoirs of stone and concrete—throwing great dams across the Mississippi and its tributaries. With these dams we not only catch the waste water which would otherwise swell the flood, but we have it where we can put it to work.

But to impound rivers and streams in reservoirs and to hold them back behind dams are remedies merely. Would it not be better to prevent floods? To keep so much water from trying to run down the Mississippi at once? Certainly it would be better! But is not that a very difficult thing to do? Yes, it is difficult, but with the help of the forests we can do it.

Of course there is no possibility that forests, however much land they cover or however thick and tall they grow, can prevent floods. How could they? Only some overwhelming

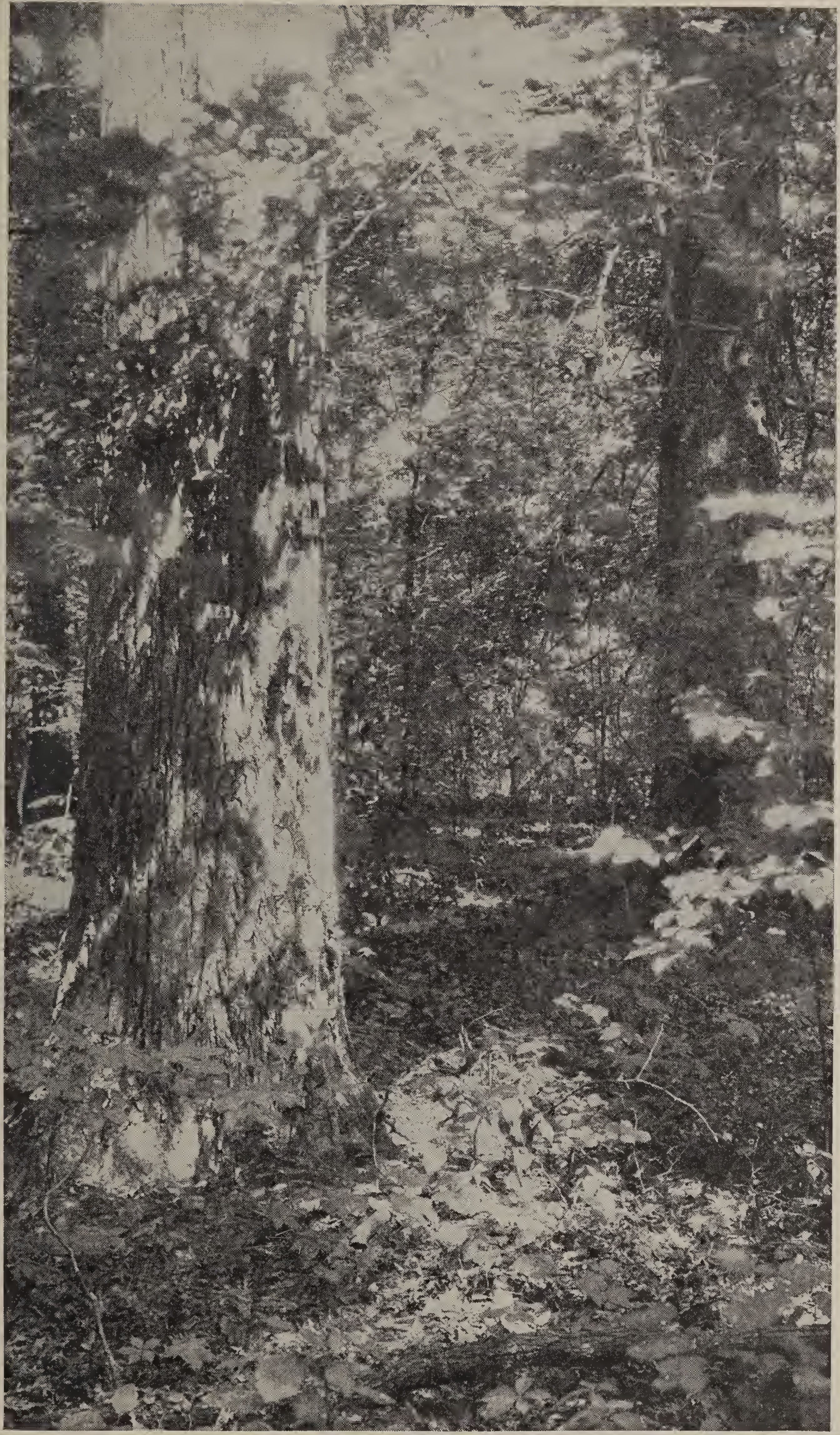
power which could say to the oceans, "Just so much water you may give up to make rain clouds of", could do this. Water that is lifted up from the ocean is certain to come down to earth again. We can do nothing when the warm air lifts water vapor from the waves, carries it over the land on a wandering erratic wind, and pours it down suddenly, except prepare the land to deal safely with it.

Forests are one means to that end. What exactly can they do?

Behind the Mississippi and her tributaries are 800,000,000 acres of land on which the floods originate in rain and melting snow. One hundred and sixty million of these acres are or can be covered with forests. What help can they give to the reservoirs, and dams, and levees in keeping the rivers in their courses?

To control floods it is necessary to interfere with that persistent force of gravitation which continually pulls water down to the level of the ocean. Nothing can hold water back when it is gathered together at the mouth of the Mississippi; almost anything can deter a raindrop.

Consider again what a forest is. Underneath the ground is a thick network of roots, strong, long fibers which keep the loose soil made spongy by wood mold, porous enough to hold water. Upon the forest floors lies the duff, a layer of branches, dead grasses, and leaves which may be as much as a foot thick. In through it are mosses and ferns. Now moss can absorb from 200 to 900 times its weight in water. If the dead leaves on the forest floor are from birch, maple, or other hardwoods, they will absorb 150 to 220 times their weight. If they are pine needles they will absorb from 120 to 135 times their weight. Such a porous mat will hold a a good deal of water, especially if this is not hurled down upon it so rapidly that the forest floor has no time to take it in. Rain coming down on the forest in summer is met first by the thick canopy of leaves which so breaks its fall that it drips quietly upon the undergrowth and from there slides gradually to the litter on the forest floor. Some of it stops there in the cups which the dead leaves make of themselves—



Forest Floor

hard dead oak leaves which will each hold a big tablespoonful of water, maple leaves which hold half as much, star gum leaves brimming like bowls. Each one of these tiny reservoirs is small in itself, but consider how many leaves there are! The water they hold stays there till it dries. In winter the leafless branches of the trees form a windbreak. The snow, instead of being piled up in drifts, sifts down upon the forest floor. In evergreen forests much of it stays on the branches. As spring comes on, melting begins early in the woods, but it takes from four to eight times as long for the same amount of snow to melt in the forest as it does on the open ground, and since the soil in the forest is less likely to be frozen, more of the snow water can soak down into it. The roots of the trees absorb this water and carry it to the leaves, and the leaves gives it back to the air by a process called transpiration. In a year an acre of spruce will transpire the equivalent of 8½ inches of rain over that area; an acre of oak, 5 inches; an acre of beech, 10 inches. These are the equivalent of very heavy rains, and so far as floods are concerned it is as though the rains had not fallen. Only when there is more rain than can be absorbed by the soil or drawn up by the trees is there any to run off in the forest streams; only when there is a great deal more, do the streams overflow. If the streams do not overflow, neither do the rivers.

The place to prevent a flood is not at the mouth of a river, nor along its course, but where it starts—around the little forest streams on the steep hillsides and the remote rivers, and the brooks in the midst of the forests.

How does the wind affect our land? For longer than man has been on earth the wind has been busy altering the contour of the earth's surface, picking the soil up in one place and laying it down in another. There are parts of eastern China where the wind has laid down 60 feet of soil which it probably brought from the dry lands far to the west and the bare mountainsides to the south. Great deposits of wind-blown earth are also found in Washington, Idaho, and through the Great Plains region of the United States. Until plants—grasses and trees—began slowly to creep over the land and to hold it in place with their roots, there was nothing to prevent the wind from carrying the soil wherever it chose.

In simple terms wind is only air traveling from one place to another. The movement usually is from a place where the air is heavy and cool to a place where it is light and warm. Air acts exactly like the people of a crowded country who emigrate to a new land where there is more room.

The Prairie-Plains region of this country has comparatively few trees. Also certain conditions—high winds, high temperatures, dry winds, blizzards, hail, and drought—are distinct hazards to crop agriculture in this region. So delicate is the natural balance that a slight reduction in rainfall, a rise of a few degrees in temperature, or accelerated wind movement may affect crops seriously. On the other hand, such slight changes as may be affected by a field windbreak, may bring about that fine adjustment that is necessary to prevent damage to soil and crops. It is, of course, not true that tree windbreaks will cure all the ills that afflict the Plains region. Other corrective measures are required.

Everyone who has taken refuge from a blow on the lee side of a grove knows that the trees break the force of the wind. Scientists who have studied effects of barriers have found there may be as much as 25-percent reduction in the speed of wind at a distance as much as 20 times the height of the barrier. At 35 to 40 times its height the reduction may be 10 percent. If a tree barrier is 50 feet high, and many field windbreaks will reach that height, it would there-

A. Tree Plantation on the Howard Farm, Orchard, Nebr. B. The Same Windbreak Three Seasons Later.

fore have a protective effect on an area at least 1,000 feet in the lee of the planting. Moreover, there is also a slowing of the wind on the windward side up to about 5 times the height of the barrier.

Since trees can play such an important part in the betterment of an agricultural region, the Forest Service was asked in 1934 to initiate a program of systematic planning and planting of tree windbreaks in cooperation with the farmers in the Prairie-Plains region. The first plantings in this undertaking were made in 1935, and the work is now being carried on by the Prairie States forestry project. Naturally, some changes in procedure and policy have been made since the first trees were planted, but the aim—improvement of agricultural and living conditions in the Plains region—has not changed.

Tree planting for the betterment of an agricultural region is not a new idea. Foresters and agriculturists have long been studying the effects of tree windbreaks on agricultural crops and their general effect on the social and economic problems of a region. Their importance to agriculture has been demonstrated in many parts of the United States. In the coastal regions, along the Great Lakes and along the Columbia River in Oregon and Washington, trees have been planted to help check and to give protection against encroaching sand dunes. In the fruit-growing valleys of western Colorado and in the citrus districts of California windbreaks are used to protect the orchard trees and to conserve precious irrigation water against the drying effect of mountain-to-valley winds. In southern Minnesota and Indiana eastward, where the peat soils receive enough moisture to make their cultivation highly productive, windbreaks are used to keep these featherweight soils from blowing away. Also in the Plains region a number of earlier efforts were made to stimulate tree growing and as a result there have been many millions of trees planted.

Many of the tree windbreaks planted on the Plains in the early days are still thriving and serving a very useful purpose.

As was to be expected, there were also many failures, but these failures also served a very useful purpose. They

served as laboratories for studying the causes for failure. The Forest Service and the Bureau of Plant Industry have studied these tree plantings, and as a result we now know why some of them failed while others were successful. We know that the primary reasons for the failure of many of the plantings were the use of wrong species of trees, the use of trees or seed of improper source, lack of protection from livestock and rodents, improper cultivation or lack of cultivation, particularly in the early life of the plantation, attempting to grow trees on soils unable to support tree growth, and attempting to grow trees where rainfall is not sufficient without taking steps to divert supplemental moisture to the trees. We have learned how and where trees can be grown successfully and much about the effect of tree windbreaks on the agricultural economy of the region.

But specifically, what are the beneficial effects of shelterbelts, and how do they affect the social and economic conditions of a region such as the Prairie-Plains?

Of primary consideration in the Plains region is the protection of the fertile topsoil, which is our basic resource. Trees are the best known means of protecting sandy soil from wind erosion. Other measures, such as listing and strip cropping, are used but these are temporary. Continued protection depends upon the operator carrying out these practices year after year. Field tree windbreaks, on the other hand, are permanent fixtures. Once established, they cost very little to maintain.

Tree windbreaks help to insure crops. They protect newly sown fields so that the seed is not blown out or covered up. This is particularly important in the more sandy areas of the South where seedlings sometimes blow out as many as four times. Also newly germinated seedlings, particularly those of cotton and corn, are often cut off by swirling sand in unprotected fields. Some crops, such as corn, may be fired or burned in a short period of only a few days by the hot south winds that draw moisture from the plants faster than they can be supplied with moisture from the soil. Wheat and other small grains are also very often severely

damaged by the hot withering south winds. The protection afforded by a planting of trees during such critical periods often saves the crops from complete failure. An increase in the average crop yield results from such protection.

Greater diversification of the cropping system can be practiced if the land is adequately protected by field windbreaks of trees. They make possible the growing of a truck garden, an orchard, and perhaps other crops that swing the economy of the farm away from a purely cash-crop basis.

Other very tangible benefits of windbreak planting are the tempering of the extremes, the windbreak furnishing protection to man and beast from the cold winds of winter. This results in a reduction in fuel requirements for heating the home and in the food requirements for livestock.

Tree windbreaks yield much-needed wood products such as fuel and fence posts, which reduce the operating cost of the farm and contribute to the well-being of the farm family. They also furnish food and protection to game and other insect-eating birds.

That trees about a farm enhance its value and give to its inhabitants added pride and contentment in their home is beyond doubt. Windbreaks about the home make it possible to plant other shade trees, ornamentals, and flower gardens. Every windbreak is a potential recreational area for the farm family, particularly for the children.

In the Northern States the tree windbreaks also have a pronounced influence in holding the snow on the fields instead of permitting it to be swept into gullies, where it is not only lost to crops but contributes to the water-erosion and flood problems of early spring.

All of these benefits aid the farm family economically and socially and are reflected in the community, the State, and the Nation.

Extensive tree planting over the entire Plains region cannot, of course, be economically justified. Generally speaking, west of the one hundredth meridian or in the areas where the rainfall is below 16 to 18 inches annually, the feasibility of tree planting becomes questionable and such plantings

are therefore restricted to fewer uses. This area is generally range country, and farming in much of it is extremely hazardous.

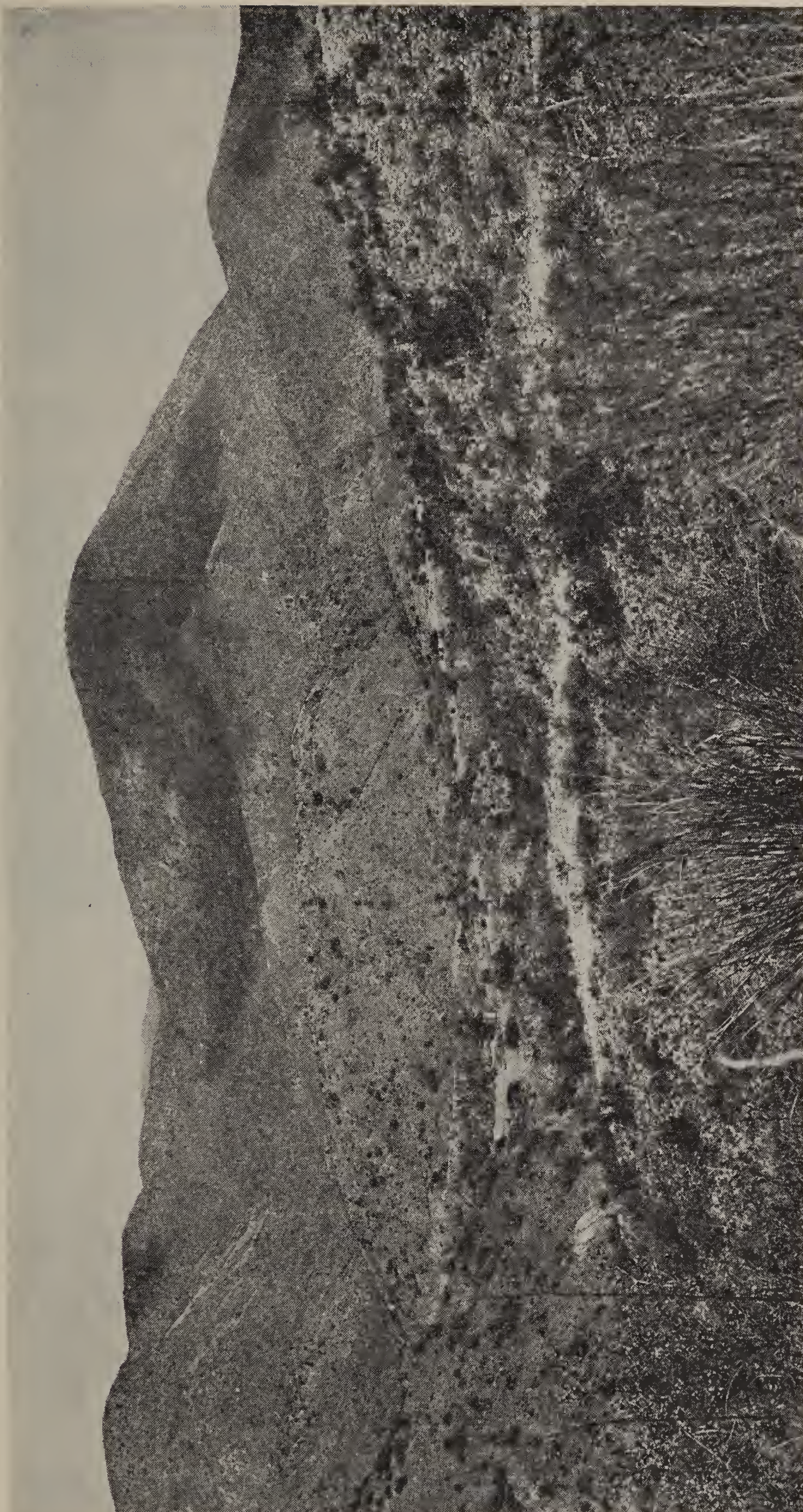
In the area where rainfall is above 30 inches annually, or roughly east of the ninety-seventh meridian, successful tree planting is comparatively simple. Generally speaking, farms in this area now have over 7 percent of their acreage in trees, principally natural timber that has been retained.

Between the ninety-seventh and one hundredth meridians is the problem area of the Plains. Much of this area is threatened with severe wind erosion, the fertility of thousands of acres having already been destroyed. Because of its importance to the Nation, this agricultural area must be protected and so managed that it will remain permanently productive. It is largely within this area that the work of the Prairie States forestry project has been carried on.

The Prairie States forestry project is at the present time planning and planting only the framework, so to speak, of the field windbreaks necessary for complete protection. This framework planting consists of the establishment of basic windbreaks at approximately ½-mile intervals, insofar as possible at right angles to the prevailing or the most destructive winds on all suitable cultivated farm land. In some areas where the soil-blowing problem is exceptionally acute, one- to three-row intermediate plantings are also made between the basic windbreaks to give complete protection to the soil as quickly as possible.

The basic plantings usually consist of 10 rows of trees, the rows being 8 to 10 feet apart and the trees in each row from 6 to 8 feet apart. The shrub species which are in the first or outside row are planted from 3 to 4 feet apart.

All species of trees are not suitable for windbreak planting. Each site is examined, and the kinds of trees best suited to that particular site are selected. Also, of course, consideration is given to the moisture that will be available for tree growth and to other climatic factors. It is a fact that trees planted in a region climatically different from that of the seed source do not do so well. In other words, hackberry



Southwest forests.

grown from seed collected in Texas is not suitable for planting in South Dakota, or a tree suitable to the relatively moist eastern section of a State may not be adapted to the dry western sections.

A. Effect of Tree Windbreak on Wind Velocity. B. Field Windbreak, Nebraska.

The tree species are also selected so that the windbreak will meet certain standards or qualifications. First, the shelterbelt must become effective as quickly as possible, which means fast-growing trees must be used. The fastest-growing trees suitable to the conditions in the Plains region are cottonwood and Chinese elm. One or both of these species are used in every planting if possible.

The area protected by a field windbreak is in direct relation to its height; the higher the trees the greater the area protected. Tall-growing species must therefore be provided. Again cottonwood and Chinese elm best fill this purpose although there are other species, ordinarily termed

intermediate trees, which may eventually grow as tall as the cottonwood and Chinese elm but are slower growing.

In order to add permanence, provide species valuable for their wood products and other uses, and to strengthen the planting as a wind barrier, four or five rows of intermediate growing trees are used. Species classified as intermediates are green ash, American elm, mulberry, hackberry, apricot, black walnut, bur oak, honeylocust, black locust, Osage-orange, boxelder, and catalpa.

It is the aim to make the protective plantings more or less permanent by using long-lived species, and also to provide dense, year-long protection. The conifers meet these specifications, the red cedar, ponderosa pine, and Austrian pine being well adapted to Plains conditions.

A good windbreak must also be dense and close at the bottom. To provide this low protection, the outside row on the windward side is planted to a low-branching and comparatively low-growing shrub species such as caragana, wild plum, desert willow, or Russian-olive.

So we see even in the Prairie-Plains region trees have much to give for the benefit of the people who live there. And every field windbreak is planned to provide maximum value to the individual farm and the community.

The list of things which we get from our forests grows longer all the time. There are all those gifts which we can see and touch—board feet, and movie films, plastics and rayon, turpentine, cattle feed, and paper. There are also the things that these servants are doing for us—guarding our land, arresting water and wind, protecting our water supply, helping us to grow better crops.

But our forests have something more to give us than all this—they are laboratories, experiment stations, museums, out-of-door classrooms for scientific study.

Ten million acres are still about as they were when the white man came to America. They are samples of what a forest community makes of itself, in places as widely apart as Florida and Oregon. In the tropical forests of the Everglades we can see the beautiful and terrible strangler fig letting down its roots from the branches of a live oak, wrapping it around closer and closer till the tree dies. We see the parent of the papaya and the remote ancestors of the rubber tree—we see tree snails that would die with the first frost and alligators which are the nearest things we have on this continent to the strange reptiles which once ruled the earth. In the dry, hot, cactus country of the Southwest are the sparse forests which have learned to store up water for use in times of drought, much as a camel does, the giant sahauro cactus that swells and shrinks with the water, the pines growing so wide apart that their roots do not steal each other's scant water supply. In the valleys of California are those oldest of living things, the great sequoias. In southern Indiana and Illinois are guarded areas where we can still see the sort of great tulip trees and sycamores which began to grow there when the glaciers, after at least six advances, finally withdrew to the Arctic Circle.

Not goods, nor service, but knowledge for its own sake do these untouched forests give us.

The Desert Forests of the Southwest—Giant Cactus—Arizona

Besides goods and services and knowledge, our forests give us the greatest playgrounds a people ever had.

From the time that we human beings began to live in communities we have been neighbors to the forests. Since we started on the long up-slant toward civilization, to go into the forest has always been an adventure. From our remote great-grandfather who ventured in under the trees step by step, his sensitive ears pricked up for any rustle of leaves or breaking twigs, his nostrils twitching for some dangerous scent, his eyes glancing right and left for some menacing thing that moved, his whole body poised to scramble up the bole of a tree at the first alarm, we who ride through the crimson autumn woods of New England on concrete highways with no more danger than that of running out of gasoline, inherit the longing for the sense of adventure that the forests give us.

That ancestor of ours must have had plenty of time to wander through the forest. Enough to eat and some sort of shelter were about all he had learned to want. When he discovered how many things he needed to make himself comfortable and happy and began to work to get them, he hadn't much leisure left. Only since we have discovered that instead of working hard and long to get what we want we can let machines work for us, have we got back some leisure. Today we are just beginning to get time to play and are returning to those early playgrounds of ours, the forests.

The forests which we own through the Nation or the different States are playgrounds open to us all and within the reach of most of us. Upward of 23 million automobiles are owned by the American people, and the smooth, hard white roads stretch out toward our forests and into them, and through them farther and farther, year by year. In 1938 more than 30 million of us passed through our forests, and 14½ million stopped over to enjoy them.

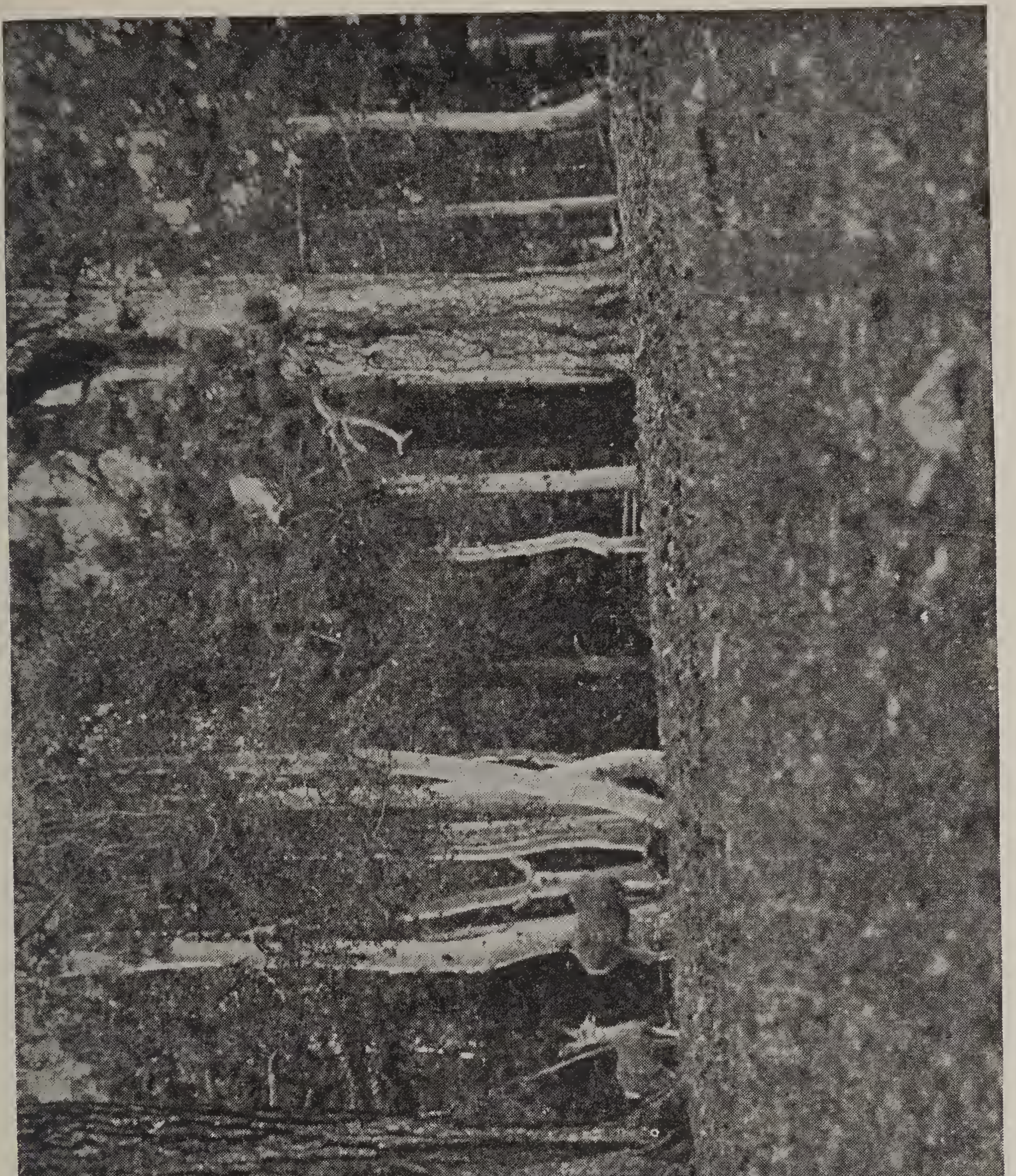
What makes them such good playgrounds? What did we do there?

In the Forest—New Hampshire

The millions of us who just rode through the forests and looked at the legions of pines and the cohorts of the hardwoods, with an occasional unregimented deer or bear for contrast, took our pleasure in a moving picture in colors. More than a third of these pleasure seekers, who come usually from the cities, picked out spots that pleased them and set up tents, or they stopped in one of the 3,000 free campgrounds which are provided with good drinking water and sanitary equipment, outdoor fireplaces, rustic tables and benches, or stayed at the inexpensive resorts on the shores of lovely lakes, or at the regular summer hotels. They stayed, these seekers after pleasure, from as little as 1 or 2 days to as long as all the months between the going of the spring snows and the coming of the autumn cold.

They seemed specially interested in finding out how the world was made. They gathered about the scars left by that great battle won by the ice ages ago—the scratches on the rocks which the glaciers had scraped bare of trees—as though they were the battlefields of the World War. They studied the mosses and lichens which after thousands of years are just anchoring a little soil into the hollows in the rocks. They hiked along trails into those 10 million acres which are kept as primitive areas—wild forests with no roads, or stores, or gas stations, and only such signs of civilization as help to guard them from fire. They got out their paint boxes and "did landscapes"; they swam in the cold forest lakes; they climbed up to the snow line, where the trees grow smaller and fewer and the air is colder and the rushing winds more bitter; they listened to the great owls talking together in the dark when their wings make no sound. One way or another they saw a good deal of the forest animals, for the hunting habit is as old as the race. If our greatest great-grandfather had not been able to knock down a little *Eohippus* with a well-thrown stone his children would have gone supperless to bed. If he had gone ahunting and *not* brought back a rabbitskin, Baby Bunting would have slept cold. No children of poor hunters could survive.

But the survival of the race does not any longer depend on

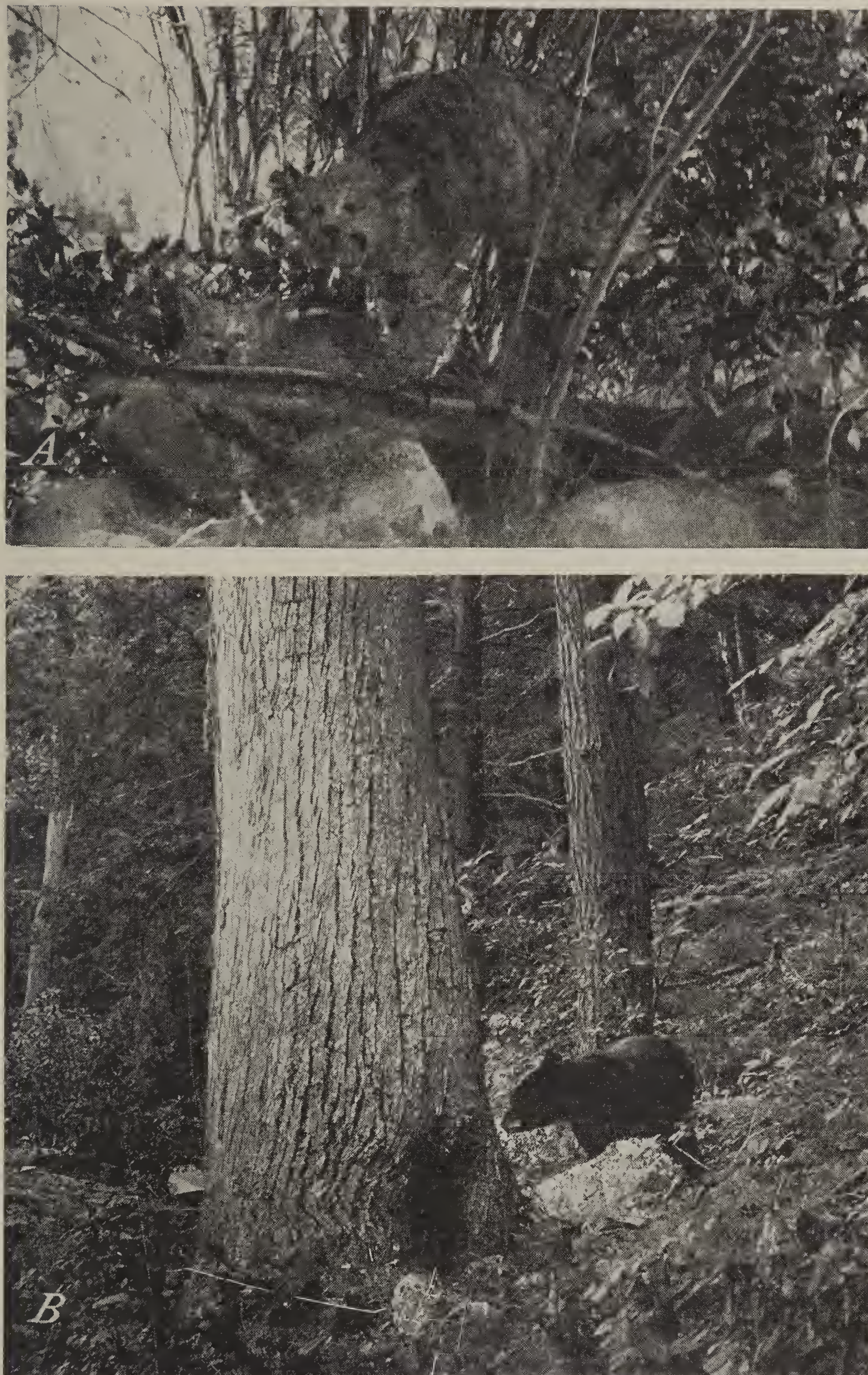


Mule Deer and Aspen.

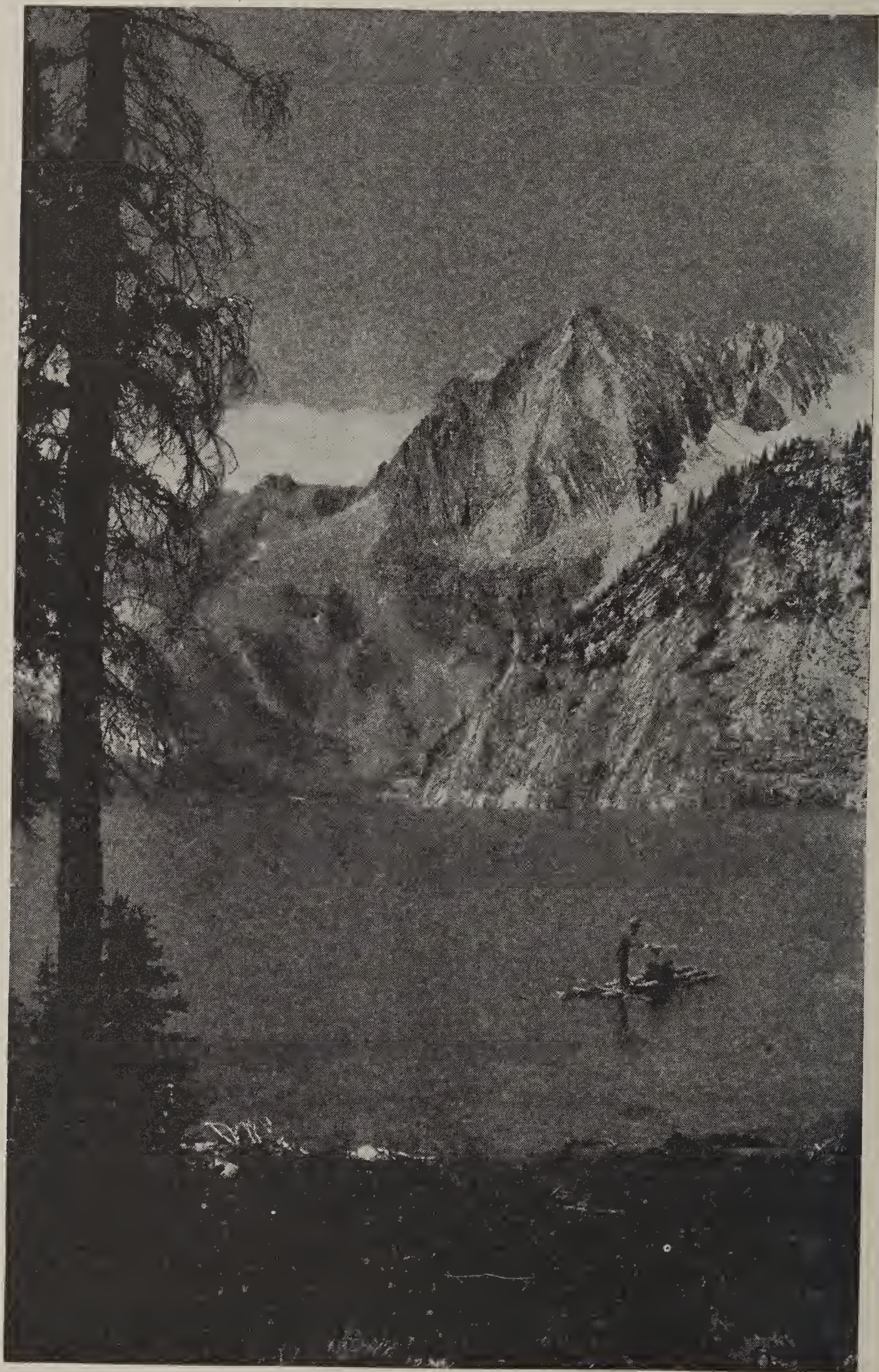
our ability to kill wild animals for food or clothing or to catch fish. Babies grow to maturity without ever having seen a rabbitskin. Families flourish in which father never baited a hook. The hunt in the forests has changed from a necessary way of getting food to a privileged way of getting pleasure, and except in the open season for some special animal and with an official permit, the weapons with which we hunt in our national forests are such peaceful things as bird glasses, cameras, and perhaps a flash to "shine for deer."

That "shining for deer" where there is no intention of killing them is an entrancing game. It must be played where the deer come down to drink in the time after the sun is set and before the moon rises. Get into a canoe and paddle without a sound along the water's edge. Your wits are against the wits of the deer and your ears and eyes against his. The other wild things are on his side. If there are loons calling out on the lake they will stop unless you know how to call back. If there are porcupines gnawing noisily they will rest and peer about in the dark when they hear you. If there are heavy-footed bears plodding about they may go crashing away through the bushes. But if no wild thing gives the alarm, and your paddle does not splash and you handle the flash well, then you may see in the sudden light you throw along the shore, two great bright eyes, a delicate nose, and dripping mouth tossed suddenly, a pale, fawn-colored body that lifts in an arching spring and whirls away into the dark.

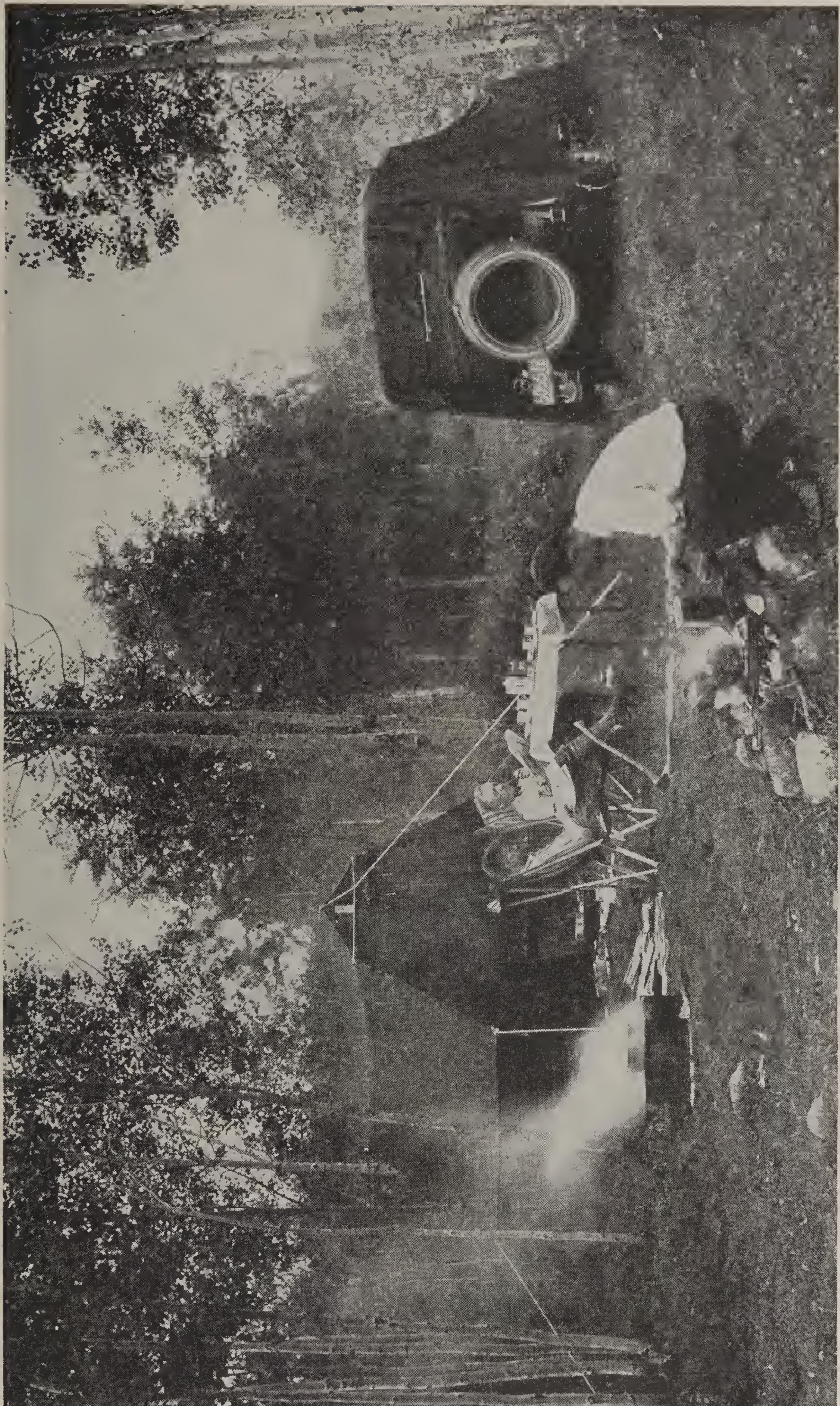
And there's that joy that the fisherman gets in the forest stream where a trout may be in the deep pool shaded by a great tree. Here again it is your wits and patience against his. He's almost invisible when he holds himself in the shadow with the dark stripe on his back toward you and no motion but the slow moving of his tail. You must guess where he lies in wait, and have some sure knowledge of what sort of food he waits for if you are going to tempt him with your bait. If you win against him you will see the rush of a dark streak and then the bright flash of his side as he turns to take the hook. This fishing is an old game, too, and like



A. Bobcats—Montana.   B. The Bear's Den—West Virginia



Fisherman's Luck—Colorado



Our Great Playgrounds—Virginia

hunting it began in those long-past days when life depended on a man's ability to win at it. Those early fishermen stood stooping above the water, slender spears pointed with chipped stone poised ready to strike the fish, or they floated in dugouts made of tree trunks and dropped in their lines of twisted sinew with hooks of bone. Their fishhooks and spear heads are in the museums. That they were successful fishermen we know because of the fish-bones in the vast piles of rubbish called kitchen middens left along the banks of streams. We still delight in the thing that our ancestors did so well.

It is not only in the summer that we go to our forests to play. More and more we are finding that we have time for winter sports. In our White Mountain forests are wonderful cleared slopes for ski jumping and tracks for coasting. During the season there are sometimes 10 railroad trains a day from the New England cities—Hartford, Springfield, Boston, and the rest—up into the forests, and about a quarter as many people play there in the winter as in the summer.

There are no rules in these great playgrounds except those which we have laid down for ourselves under the law, and no policing except what is needed for the safety of those 70 million of us who come from all over the land to enjoy them.

Road Through the Redwoods—California

Still another gift our 630,000,000 acres have for us, something that we have worked toward ever since we became human—security for those who find a new way of living within the forests. There have been temporary settlements of men as part of forest industries, but usually the result has been to destroy the other living things they found there. If a village was built as part of some commercial enterprise like mining or lumbering, it was abandoned when the mines were exhausted or the trees were cut, because there was no way left for the people in it to get a living. The remains of many such villages are in the mining country and the cut-over forest lands.

But with our increasing need for the things that forests can give us, we are learning to cultivate and preserve the forests instead of destroying them, learning to grow crops of trees as a farmer grows crops of corn. To do this we must treat tree growing as a branch of agriculture with a harvest each year. This means that a group of people will live in the forest as a farmer lives on his farm. And just as in the homes of our early farmers the things the land provided them with were manufactured before they were sold—wool was spun; wheat was ground—so in these forest cities that raw material, wood, will be transformed into the things which people use directly—lumber and paper and the rest. Since only as many trees will be cut each year as will leave an adequate harvest for the next year, and as only as many people will live in the forest cities as can find work there, these towns, founded on the certainty of a perpetual harvest, need never die, nor the people beg their bread. But like all the other gifts of the forests this security will not come of itself; it must be worked for.

Some of these forest cities are to be set up in the midst of virgin timber. The people living in them will have the chance to harvest trees already grown. They will also have land on which to grow grain and vegetables and raise animals, so that they will combine that form of agriculture which is farming with that form which is forestry.

In other forest communities, such as the Drummond Homesteads which have been established on the cut-over lands in northwestern Wisconsin, a new forest must be planted and have time to grow before there will be a crop of trees to cut. It takes a long time to grow trees—years and years—so that the forest work in Drummond is not now what it will be when the trees are ready to harvest. Thirty homes have been built there, and 160 people are living in them, and they have been provided with a community building also. These 160 people have come from places where the land is too poor to raise good crops, so that they have not been able to make a comfortable living. Here on good land, and with a harvest of farm produce as well as trees, they may be secure and prosperous again.

CONCLUSION

One-third of the United States is forest land, and from it we get wood and all the things that are made from it, laboratories for scientific study, outdoor museums, and service and protection against erosion, floods, and wind. We also get a place for sport and recreation and a chance for security. These things we can get now.

What more the forests can be made to give us in the future depends on ourselves. More in the way of food, undoubtedly—more nuts; more cattle food—more protection for land and water, a use for lignin that will satisfy some new need, more pleasure, and increasing security.

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